TCRP SYNTHESIS 64

TRANSIT COOPERATIVE RESEARCH PROGRAM

Sponsored by
the Federal
Transit Administration

Bus Use of Shoulders

A Synthesis of Transit Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP SYNTHESIS 64

Bus Use of Shoulders

A Synthesis of Transit Practice

CONSULTANT
PETER C. MARTIN
Wilbur Smith Associates
San Francisco, California

SUBJECT AREAS
Public Transit

Research Sponsored by the Federal Transit Administration in Cooperation with
the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2006
www.TRB.org

TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by TRB. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

TCRP SYNTHESIS 64

Price $35.00

Project J-7, Topic SD-03
ISSN 1073-4880
ISBN 0-309-09767-3
Library of Congress Control Number 2006925244

NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the Transit Development Corporation, the National Research Council, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

The Transportation Research Board of The National Academies, the Transit Development Corporation, the National Research Council, and the Federal Transit Administration (sponsor of the Transit Cooperative Research Program) do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

Published reports of the

TRANSIT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at
http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. William A. Wulf are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is a division of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to promote innovation and progress in transportation through research. In an objective and interdisciplinary setting, the Board facilitates the sharing of information on transportation practice and policy by researchers and practitioners; stimulates research and offers research management services that promote technical excellence; provides expert advice on transportation policy and programs; and disseminates research results broadly and encourages their implementation. The Board's varied activities annually engage more than 5,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

TCRP COMMITTEE FOR PROJECT J-7

CHAIR
FRANK T. MARTIN
PBS&J, Tallahassee, FL

MEMBERS
DEBRA W. ALEXANDER
Capital Area Transportation Authority, Lansing, MI
DWIGHT FERRELL
The Ferrell Group, Richardson, TX
MARK W. FURHMANN
Metro Transit, Minneapolis, MN
ROBERT H. IRWIN
British Columbia Transit, Victoria, BC, Canada
PAUL J. LARROUSSE
National Transit Institute, New Brunswick, NJ
WADE LAWSON
South Jersey Transportation Authority, Atlantic City, NJ
DAVID A. LEE
Connecticut Transit, Hartford, CT
DAVID PHELPS
Consultant, Moneta, VA
HAYWARD M. SEYMORE, III
Laidlaw Transit Services, Inc., University Place, WA
PAM WARD
Ottumwa Transit Authority, Ottumwa, IA
JOEL R. WASHINGTON
Washington Metropolitan Area Transit Authority, Washington, DC

FTA LIAISON
KAREN FACEN
Federal Highway Administration

TRB LIAISON
PETER SHAW
Transportation Research Board

COOPERATIVE RESEARCH PROGRAM STAFF
ROBERT J. REILLY, *Director, Cooperative Research Programs*
CHRISTOPHER W. JENKS, *Manager, TCRP*
EILEEN DELANEY, *Director of Publications*

TCRP SYNTHESIS STAFF
STEPHEN R. GODWIN, *Director for Studies and Information Services*
JON WILLIAMS, *Manager, Synthesis Studies*
DONNA L. VLASAK, *Senior Program Officer*
DON TIPPMAN, *Editor*
CHERYL Y. KEITH, *Senior Secretary*

TOPIC PANEL
GRAHAM CAREY, *Lane Transit District*
RON DROLET, *British Columbia Transit*
RICHARD A. CUNARD, *Transportation Research Board*
AARON ISAACS, *Twin Cities Metro Transit*
HERBERT S. LEVINSON, *New Haven,Connecticut*
CATHERINE C. McGHEE, *Virginia Department of Transportation*
DAVID E. SCHUMACHER, *San Diego Association of Governments*
HAK-CHUL SHIN, *Jackson State University*
R. SCOTT ZELLER, *Washington State Department of Transportation*
JEFFREY A. LINDLEY, *Federal Highway Administration* (Liaison)
VENKAT PINDIPROLU, *Federal Transit Administration* (Liaison)

FOREWORD

By Staff
Transportation
Research Board

Transit administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the transit industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire transit community, the Transit Cooperative Research Program Oversight and Project Selection (TOPS) Committee authorized the Transportation Research Board to undertake a continuing study. This study, TCRP Project J-7, "Synthesis of Information Related to Transit Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute a TCRP report series, *Synthesis of Transit Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis documents and summarizes transit agencies' experiences with policies and regulations that permit buses to use shoulders on arterial roads or freeways to bypass congestion either as interim or long-term treatments. Both the transit and highway perspectives are explored. The purpose is to identify and obtain information and experience about jurisdictions that allow bus use of shoulders and about how jurisdictions have considered, but have not implemented, these treatments and the reasons why. This topic will be of interest to transit agency and highway organization staff responsible for bus use of shoulders. They can use this report to learn from and compare their experiences with the experiences of other agencies.

Findings in this report are based on a literature review, surveys of selected transit agencies and roadway jurisdictions, analysis of documentation submitted, as well as interviews and site visits. Case study descriptions were prepared for the following six regions: Minneapolis–St. Paul Twin Cities (Minnesota); Falls Church, Virginia; Miami, Florida; San Diego, California; Toronto, Canada; and Dublin, Ireland.

Peter C. Martin, Wilbur Smith Associates, San Francisco, California, collected and synthesized the information and wrote the paper, under the guidance of a panel of experts in the subject area. The members of the Topic Panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

BUS USE OF SHOULDERS

SUMMARY

In many urban areas, traffic congestion commonly delays bus services and adversely affects schedule reliability. Some communities have adopted policies and regulations that permit buses to use shoulders on arterial roads or freeways to bypass congestion either as interim or long-term treatments. Delaware, Georgia, Maryland, Minnesota, New Jersey, Washington, Virginia, British Columbia, and Ontario are among the jurisdictions that have implemented or are considering implementing bus use of shoulder programs. Many jurisdictions, however, have been reluctant to embrace bus use of shoulders for various reasons. Little information has been available about the affects on travel time, reliability, patronage benefits, and safety resulting from the allowed use of shoulders.

In parts of the United States, bus use of highway shoulders to bypass congestion has been in operation for more than 10 years. It represents a low-cost and relatively quick strategy to improve bus running times and reliability without requiring costly expansion of the highway right-of-way. Because the bus shoulder operations can be implemented within the highway right-of-way, minimal disruption and traffic impacts result. The shoulder bus operations also facilitate the development of rail transit-like "station stopping" service, because buses can easily enter and exit the highway. This station stopping service can only be accomplished at great expense for bus services that use median high-occupancy vehicle (HOV) lanes, because buses on these median facilities generally must maneuver across general traffic to get to and from the HOV lanes and the highway on- and off-ramps. The solution to the weaving problem is to construct expensive HOV direct access ramps.

The purpose of this synthesis is to

- Identify and obtain information about jurisdictions that allow bus use of shoulders, along with their positive and negative experiences; and
- Identify and obtain information about those jurisdictions that have considered, but have not implemented, these treatments and the reasons why.

Both the transit and highway perspectives on the bus use of shoulders are explored, recognizing that they must be partners in expanding promising applications for increasing patronage and improving operating efficiency. In this report, BBS stands for bus bypass shoulder operations. This acronym is used by other countries to describe their bus shoulder congestion bypass operations.

Screening surveys were distributed to U.S. state departments of transportation, Canadian provincial transit agencies, transit operators, metropolitan planning organizations, and other agencies. Seventy-one responses were received.

BBS operations have proven popular with bus passengers who benefit from the improved schedule reliability and quicker travel times. Such operations also have improved bus operating efficiencies and have not drawn significant complaints from general traffic motorists. Positive passenger perception of travel time savings helps to attract patronage. Passengers enjoy the feeling of moving faster than the general traffic. For bus operators, BBS operations

allow them to offer more reliable service, which is particularly important for buses that make more than one peak direction commute period trip; the second peak direction bus trip is more likely to be on time. Other attractive aspects of BBS applications are that they can be implemented relatively quickly and are very cost-effective owing to their low cost. BBS projects typically do not require new rights-of-way and visually they are much less obtrusive than other capacity enhancements such as widened highways and direct-ramp interchange. In addition, BBS operations lend themselves to station stopping express bus service on freeways, because entering and exiting the freeway involve minimal traffic conflicts.

From a highway operations and safety viewpoint the BBS use operations raise a number of important concerns. These concerns encompass the loss of basic functions that shoulders are intended to provide (removal and storage of disabled vehicles, emergency vehicle access, and highway maintenance staging), traffic safety risks, and the added costs for maintenance and enforcement. The traffic safety concerns include:

- Conflicts at on- and off-ramps;
- Sight distance adequacy, particularly at on-ramps;
- Conflicts for motorists pulling onto the shoulder;
- Loss of safe evasive movement shelter area;
- Need for bus driver training;
- Speed differential;
- Impact on adjacent lane motorists;
- Return merge distance adequacy;
- Shoulder area debris hazards;
- Reduced clearance for buses at bridge abutments; and
- Highway drainage.

Although a number of agencies have been constructing shoulders to full traffic lane standards, implementing BBS operations on older freeways often necessitates upgrades to shoulders. Many highway shoulders are 10 ft wide or less and are not constructed to support high volumes of bus traffic. Buses themselves are nearly 10 ft wide, including mirrors, and are very heavy vehicles. Drainage side slopes and catch basins sometimes also need modification to provide comfortable bus rides. Signage and pavement markings also must be provided for safe operations. The extent of these modifications varies by jurisdiction and by highway.

This synthesis project has further defined the bus use of shoulder facilities in North America and provides added information on its implementation. Not unexpectedly, consistently formatted information describing these projects is not available, because they are low cost and not subject to the rigid and structured planning analysis requirements of a single national agency.

What appears clear is that with proper operating rules and prudent upgrades to shoulder facilities the bus use of shoulders to bypass congestion has been a success. Successful concepts are copied and the bus shoulder congestion bypass concept has been copied and currently appears to be expanding into new communities. Its current use in most communities, however, is limited to a few corridors with significant bus operations, congested traffic conditions, and limited opportunities to widen the highway.

CHAPTER ONE

INTRODUCTION

BACKGROUND

In many urban areas, traffic congestion regularly delays bus services and adversely affects schedule reliability. Many communities have adopted measures such as bus priority lanes, bus signal priorities, or improved fare collection policies to improve speed and reliability. Some communities have adopted policies and regulations that permit buses to use arterial or freeway shoulders to bypass congestion either as interim or long-term treatments. At the outset of the study, Maryland, Minnesota, Virginia, Washington, British Columbia, and Ontario were among the jurisdictions that had implemented or were considering implementing bus use of shoulder programs. However, because little information was available about travel time, reliability, patronage benefits, and safety impacts resulting from allowed use of shoulders, many jurisdictions have been reluctant to embrace bus use of shoulders.

Buses bypassing traffic congestion on shoulder lanes can help make bus use more attractive. Travel time reliability and travel time competitiveness are both key factors that attract "choice riders" to bus transportation. These are basic advantages that rail and bus systems operating on exclusive rights-of-way provide, and they help to explain why these systems are more successful than conventional bus services operating in mixed-use traffic. The marketing and psychological message of buses passing motorists stuck in traffic congestion tends to be powerful. In essence, bus bypass shoulder (BBS) use operations reduce passenger travel times and help improve travel time reliability.

BBS is used by a number of agencies to describe bus use of shoulders. This acronym was adopted for use in this report and is suggested for use in subsequent technical reports.

Along many congested freeway corridors, widening to provide a bus-only lane is not a viable option because of right-of-way constraints, environmental concerns, and/or high cost. In these restricted corridors the use of outside shoulders by buses to bypass congestion provides a means to increase the person carrying capacity of the corridor without expanding rights-of-way. The shoulder use concept is less disruptive than widening projects to implement, is relatively low cost, and can be put into practice relatively quickly. Visually, the BBS concept is less obtrusive than large highway ramps constructed to allow buses direct access into center median high-occupancy vehicle (HOV) lanes.

A potential application for BBS is to support "station stopping" bus operation along highways with center median HOV lanes. Station stopping buses follow bus routes that make many passenger stops at interchanges along a corridor. This mode of bus operation is similar to the operation of most light rail systems, which make station stops approximately every mile along major travel corridors. Use of median HOV lanes for station stopping bus routes tends to be very challenging, particularly where freeway buses stop at each interchange or every other interchange. These short station distances make bus weaving to and from the median HOV lanes problematic. Significant time is lost, disruption is increased to the HOV traffic flow and intervening travel lanes, and safety concerns arise with these short distance bus weaves. To contend with these issues a number of agencies have constructed expensive direct access ramps to the HOV lanes.

Another potential application is that of a "queue jumper," allowing buses to bypass congestion at a traffic bottleneck. These applications tend to be short and to involve no or only minimum ramp weaving conflicts. The short lengths of these queue jumper applications often require minimal shoulder upgrade cost and can provide significant travel time and reliability benefits.

Permitting buses to use shoulder lanes to bypass congestion, however, raises potential conflicts with the intended purpose of shoulder facilities. Highway shoulders generally provide space for disabled vehicles, emergency services, and enforcement efforts. They also provide a safety buffer and recovery area between the general travel lanes and lateral obstructions. In snow climate areas they can be used for temporary snow removal. They are not intended to be used for debris storage, but sometimes serve this function. Allowing buses to use the shoulder lanes therefore compromises these basic shoulder functions. The extent of these compromises varies by corridor and is difficult to quantify.

Another important issue is that most shoulders are not constructed to the full structural requirement as general traffic lanes and most are narrower than conventional traffic lanes. Design requirements for shoulder facilities vary by state and have included upgrades over the years. Older highways tend to have the narrowest and least accommodating design standards. AASHTO's *A Policy on Geometric Designs of Highways and Streets* (*1*) currently recommends a minimum 10-ft-wide right shoulder for highways with modest volumes of trucks (fewer than 250 trucks per hour) and 12 ft wide for highways with high truck volumes. Shoulder cross slopes for drainage purposes are typically 2% to 6%. Some shoulders also have storm drain catch basins and electrical junction boxes located within their right-of-way. The cost and right-of-way implications on adjacent lane widths may therefore become a problem in converting the shoulder facilities to accommodate heavy buses.

Safety is always an important issue. In addition to concerns raised about compromising the intended functions for freeway shoulders, concerns exist regarding increased accident risk. Most motorists do not expect traffic in the shoulder "lane" and therefore the potential for accidents increases for basic on- and off-ramp traffic maneuvers as well as for motorists moving onto the shoulder when their vehicle becomes disabled.

A number of communities allow general traffic to use shoulder lanes during peak commute times. This TCRP synthesis report focuses only on shoulder use applications restricted to buses.

SCOPE

The two purposes of this synthesis are to:

1. Identify and obtain information and experiences about jurisdictions that allow bus use of shoulders, and
2. Identify and obtain information about which jurisdictions have considered but have not implemented these treatments and the reasons why.

The transit and highway perspectives on bus shoulder operations are reviewed, recognizing that both must be partners in expanding promising applications for increasing patronage and improving operating efficiency. The following types of information were sought:

- Institutional setting;
- Planning, design, and implementation process;
- Legal aspects (liability, legal requirements, and vehicle codes, etc.);
- Operating guidelines (operating speeds, hours of use, driver operating instructions, etc.);
- Design standards and/or required physical improvements, including traffic markings and signage, lane widths, pavement depths, drainage, etc.;
- Maintenance and roadway performance;
- Enforcement and violation experience;
- Bus and passenger volumes;
- Impact on highway operations;
- Safety experience;
- Eligibility requirements (who may use the shoulder);
- Benefits and impacts (travel time savings, reliability improvements, affordability, ease of implementation, etc.);
- Driver and passenger attitudes;
- Costs (construction, maintenance, bus operations, etc.); and
- Use of emerging technologies.

A review of the relevant literature was combined with surveys of selected transit agencies and roadway jurisdictions to define the current state of the practice. Based on the survey results, in-depth case studies were developed to profile innovative and successful practices, as well as lessons learned, including where and why implementation did not occur. Gaps in the desired information were substantial.

DEFINITIONS AND ACRONYMS

BBS (bus bypass shoulder)—used in this report to describe bus use of highway shoulder lanes to bypass congestion. It does not include shoulders used for general traffic or on-ramp bypasses.

MUTCD—Manual of Uniform Traffic Control Devices for Streets and Highways (*2*), published by FHWA.

Station stopping—a mode of bus operations on freeways where buses on a route make stops at all or most interchanges along the corridor.

Queue jumper—physical facility that allows eligible traffic to bypass localized congestion.

HOV (high-occupancy vehicle)—generally defined as either two or more or three or more persons per vehicle.

Direct HOV access ramps—most HOV lanes are located in the median of freeways and require carpoolers and buses to weave across general traffic lanes to enter and exit the freeway using ramps located on the right side of the freeways. Direct access ramps eliminate the weaving for buses and HOVs by providing entry and exit access ramps directly to the center median HOV lanes. These direct ramps are costly, need additional rights-of-way, and add to the visual impact of freeway interchanges.

REPORT ORGANIZATION

Following the introductory chapter, the synthesis provides an overview of findings (chapter two), which is followed by case studies (chapter three) and the conclusions and suggested areas for further research (chapter four). Case study descriptions were prepared for the Minneapolis–St. Paul Twin Cities Area; Falls Church, Virginia; Miami, Florida; San Diego, California; Toronto, Canada; and Dublin, Ireland. Survey questionnaire tools and respondents are identified in the appendixes.

CHAPTER TWO

OVERVIEW OF FINDINGS

This chapter provides an overview of survey findings, presents the experience of areas where projects have been implemented or planned, identifies salient concerns, describes operational experience, and discusses intelligent transportation systems (ITS) applications. Detailed discussion of selected case studies are presented in chapter three and Appendix C contains supporting materials.

SURVEY RESPONSES

Seventy-one responses to the screening survey were received. Respondent agencies included 17 transit operators, 27 state or provincial departments of transportation (DOTs), 25 metropolitan planning organizations (MPOs), and two other agencies (motor vehicle commission and turnpike authority). Appendix B identifies the 71 responding agencies.

Locations with BBSs were divided into two groups:

- Current applications and
- Potential new bus use of shoulder projects.

Following a description of these shoulder use projects, general features of the current and planned shoulder use applications are described.

CURRENT BUS USE OF SHOULDER LOCATIONS

A primary purpose of the synthesis project was to identify current and planned bus shoulder use projects in North America. At the outset of the study, applications were understood to exist in four states and two provinces: Maryland, Minnesota, Virginia, Washington, British Columbia, and Ontario

The screening survey confirmed bus shoulder use applications in these six regions and identified several more locations. Some of the bus shoulder applications are continuous lanes, whereas others are essentially queue jumpers. Table 1 summarizes current and planned BBS operations. These BBS projects are described in the following order:

- Minnesota, Twin Cities Area (Case Study 1)
- Virginia, Falls Church Area (Case Study 2)
- Maryland, Metro Washington, D.C. Area
- Delaware, Wilmington Area
- New Jersey, Central Area
- Georgia, Atlanta Metro Area
- Washington, Seattle Area
- Miami, Florida (Case Study 3)
- San Diego, California (Case Study 4)
- Ottawa, Ontario
- Toronto, Ontario (Case Study 5)
- Vancouver, British Columbia
- Dublin, Ireland (Case Study 6)
- Auckland, New Zealand.

Overview descriptions are provided in this section for the six case study BBS applications, with more detailed information provided in the next section of the report.

Minnesota, Twin Cities Area

The Minneapolis–St. Paul Twin Cities area is at the forefront of implementation and operations of the bus use of shoulder concept in the United States (see Case Study 1). It is currently operating approximately 230 mi of bus shoulder use highway segments. As such, a comprehensive network of bus shoulder use facilities is provided. The network has planned for expansion to nearly 300 mi by 2007. Approximately 400 buses operating on 14 routes use the bus shoulder facilities to bypass congestion. Bus drivers have the option of using the designated bus shoulder facilities whenever speeds in the general traffic lanes drop below 35 mph. The BBS system involves a minimal level of BBS signing and no special pavement markings. Signs are periodically placed along a shoulder designating it for “Authorized Buses Only.” Warning signs (“Watch for Buses on Shoulders”) are also provided along on-ramps before the merge with shoulder and freeway traffic. Small yellow advisory signs are posted along the shoulder at places where the shoulder narrows. The initial application of BBS in the Twin Cities area was on an arterial highway. After a major flood, the BBS concept was expanded to include freeway segments and it has continued to expand.

Virginia, Falls Church Area

The Virginia DOT allows public transit buses to use a 1.3-mi segment of the shoulder on the inbound direction of the Dulles Access Highway (Route 267) to facilitate bus access to the West Falls Church Metrorail station. The shoulder lane allows

TABLE 1
SUMMARY OF BUS BYPASS SHOULDER PROJECTS

Location	Type	Description	Use	Status
Metropolitan Minneapolis–St. Paul Twin Cities Area (Minnesota)	Comprehensive network	230 mi	No BBS time restrictions, primarily transit buses, speeds limited to use when congestion slows to 35 mph—buses allowed to move 15 mph faster than general traffic	Continually expanding since 1991
Virginia near Falls Church	Eastbound queue jumper on Route 267	1.3-mi segment with no interchange weaves	Buses limited to maximum speed of 25 mph between 4 and 8 p.m.	Appears to have been operational for some years
Maryland near Burtonsville	US-29 southbound and northbound corridor	4-mi arterial hwy. segment with several signalized junctions	SB 6 to 9 a.m. NB 3 to 8 p.m. No information on maximum bus speed	Appears to have been operational for some years
Maryland near Bethesda	I-495 northbound queue jump of I-270 interchange	About 3 mi in length	NB 6 to 9 a.m. NB 3 to 7 p.m. No information on maximum bus speed	Appears to have been operational for several years
Washington Seattle Region	SR-520 westbound corridor BBS	2.7 mi with several interchanges	Buses and 3+ carpools use shoulder lane, no restrictions on speed or time of day	Early 1970s
Washington Seattle Region	SR-522 arterial BBS corridor	2.2 mi with several signalized intersections	Buses only; no restriction on speed or time of day	WB opened in 1970 and EB in 1986
New Jersey near Mountainside	Route 22 eastbound BBS corridor	About 1 mi in length	Buses only; no information on speed or time-of-day limits	Appears to have been in operation some years
New Jersey near Old Bridge	Route 9 NB and SB arterial BBS	About 4 mi in length	Morning NB and evening SB, buses only, no information on speed restrictions	Nearing implementation
Georgia near Alpharetta	GA 400 freeway BBS corridor	6 mi initially expanding to 12 mi	When general traffic drops to 35 mph BBS buses allowed to run 15 mph faster	Opened on Sep. 12, 2005
Delaware near Wilmington	Route 202 southbound BBS queue jumper	About 1,500 ft with one intermediate signal	No time restriction for BBS use	Appears to have been operational for some years
Vancouver, BC	Route 1 queue jumper	NA	NA	NA
Toronto, Ontario	Highway 403 congestion bypass both directions	About 3 mi	When traffic slows to 38 mph BBS allowed 12 mph faster	Started in 2003
Ottawa, Ontario	Highways 417 and 174	About 14 mi	BBS buses allowed to operate at posted speed of 62 mph	In operation for many years
Dublin, Ireland	Many segments in the network	50 to 70 mi	Rules vary by BBS location	Expanding since 1998 initial application
Auckland, New Zealand	Several corridors	NA	No speed restrictions	Expanding since 1991
Miami, Florida Area	SR-821/SR-836 I-75/SR-826 SR-826/I-95 SR-874/SR-878	Corridor applications	When traffic slows below 35 mph	About to begin operations
California, San Diego Area	I-805/SR-52	1-year pilot BBS project of about 4 mi	When general traffic slows below 30 mph, bus allowed to move up to 10 mph faster	Opened on Dec. 2005

Notes: SB = southbound; NB = northbound; WB = westbound; EB = eastbound; NA = not available.

buses destined for the Metrorail station to bypass the congestion queue, which develops during the evening commute for the Route 267 exit movement onto I-66 (the next interchange downstream from the Metrorail station). Although the segment is relatively short, the passenger and motorist perception of travel time savings is substantial, as buses move at 25 mph past traffic stopped in the general traffic lanes. Case Study 2 describes the Dulles Access Road BBS project in more detail.

Maryland, Metro Washington DC Area

Shoulder use bus lanes are provided on US-29 southward from Burtonsville approximately halfway toward the Washington Beltway (I-495). Figure 1 shows this BBS location. US-29 is a six-lane, 50 mph arterial roadway with some signalized intersections and a few grade-separate interchanges on the northern segment (55 mph). This shoulder use project is approximately 4 mi long. The southbound lane restriction is in effect on weekdays from 6:00 to 9:00 a.m. The northbound bus shoulder use lane is operational from 3:00 to 8:00 p.m. The operation has faded diamond lane pavement markings on the shoulders and conventional HOV type signage, using the HOV diamond (Figure 2).

Another Maryland shoulder use application is in operation on the I-495 Washington Beltway near I-270 (see Figure 3). This BBS application is essentially a queue jumper for eastbound buses to bypass congestion at the I-270 interchange. The project operates from 6 a.m. to 9 a.m. and from 3 p.m. to

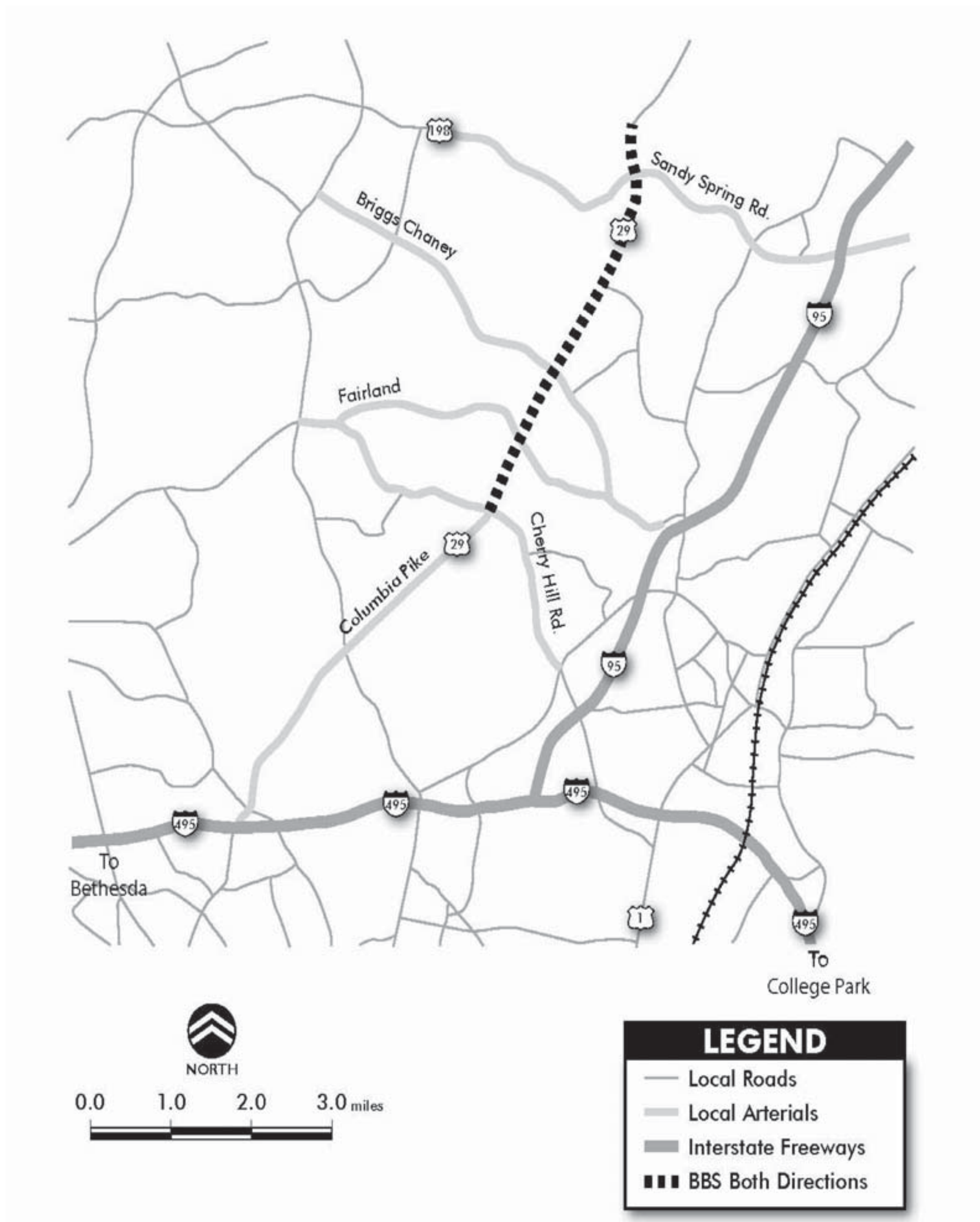


FIGURE 1 Maryland US-29 BBS location.

FIGURE 2 Maryland US-29 BBS signage.

7 p.m. Monday through Friday. I-495 has five eastbound lanes along the BBS segment and a posted speed limit of 55 mph.

Delaware, Wilmington Area

Delaware has a BBS operation on US-202 north of Wilmington The BBS application is a short queue jumper for southbound traffic that is bound toward I-95 (see Figure 4). The BBS is located between Powder Mill Road and Foulk Road for a distance of 1,500 ft. One signalized "T" intersection is located on this segment. Pavement markings and signage use the diamond symbol. Signs clearly mark the length of the BBS operation and a special bus signal indication is provided for BBS buses. The signal indication for buses is similar to a walk–don't walk display, but provides a green bus for go and a green bus with a red X for stop. The BBS operation is available to buses any hour of the day.

New Jersey, Central Area

A bus use of shoulder project is in operation on New Jersey Route 22 in Mountainside (see Figure 5). It is a short eastbound segment of an arterial road leading toward Perth Amboy. This project has minimal BBS signage ("Buses May Use Shoulder") and no special pavement markings.

The New Jersey DOT is about to implement an additional BBS project on US-9 in Middlesex County near the town of Old Bridge (Figure 6). The Old Bridge BBS project is approximately 4 mi long and is scheduled to open in mid-2007. The BBS operation will be between Spring Valley Road and Cindy Street and between Fairway Lane and Perrine Road. The project is estimated to cost approximately $8.5 million, and includes new sidewalks and pedestrian refuge islands as well as shoulder improvements. Existing 12-ft-wide shoulders will be replaced with full-depth pavement for buses. The drainage cross slopes of the shoulders will also be reduced from their current 4% to 2.5%. To maintain effective drainage, 78 new drainage inlets are planned for the BBS segment. The project is an element of New Jersey DOT's Enhanced Bus Improvement Program and is designed to reduce delays and increase on-time bus service performance. US-9 is a six-lane arterial highway with an 18-ft-wide grass median. BBS operation would serve northbound buses toward New York City during the morning commute peak period and southbound buses during the afternoon/evening commute peak period. Approximately 440 buses and 6,800 passengers use the Route 9 corridor daily. Pavement markings for the US-9 project will consist of "Bus Only" markings and signage will indicate "Bus Only" with the hours of BBS operations. The posting of "Yield to Bus" signs has been suggested for the beginning of the BBS operations. New Jersey's vehicle code includes the "yield to bus" right-of-way rule, where motorists are required to yield the right-of-way for buses merging back into traffic.

Georgia, Atlanta Metro Area

The Georgia Regional Transportation Authority and Georgia DOT opened a BBS operation on September 12, 2005, for the GA-400 freeway between the North Springs Metropolitan Atlanta Rapid Transit Authority (MARTA) rail station and Mansell Road (Figure 7). The BBS project will eventually extend northward to the Windward Parkway, connecting Alpharetta with the MARTA North Springs Station, a distance of approximately 12 mi (broken line in Figure 7). The shoulders of GA-400 were widened by 2 ft and reinforced to accommodate the shoulder use at a cost of approximately $2.8 million. The initial segment is approximately 6 mi long, and when complete the BBS will be 12 mi long. The operating plan allows MARTA buses to use shoulders when general traffic speeds drop below 35 mph. Buses are only allowed to operate at a maximum speed of 35 mph; however, they can travel no more than 15 mph faster than general traffic. To minimize conflicts at interchanges, buses are required to reenter general traffic lanes before the interchange and not to reenter the shoulder until after the interchange. Commuter buses are estimated to save between 5 and 7 min of travel time using the shoulders and might save up to 25 min at times when major disruptions occur. A change in the vehicle code was required to permit buses to use the shoulder lanes.

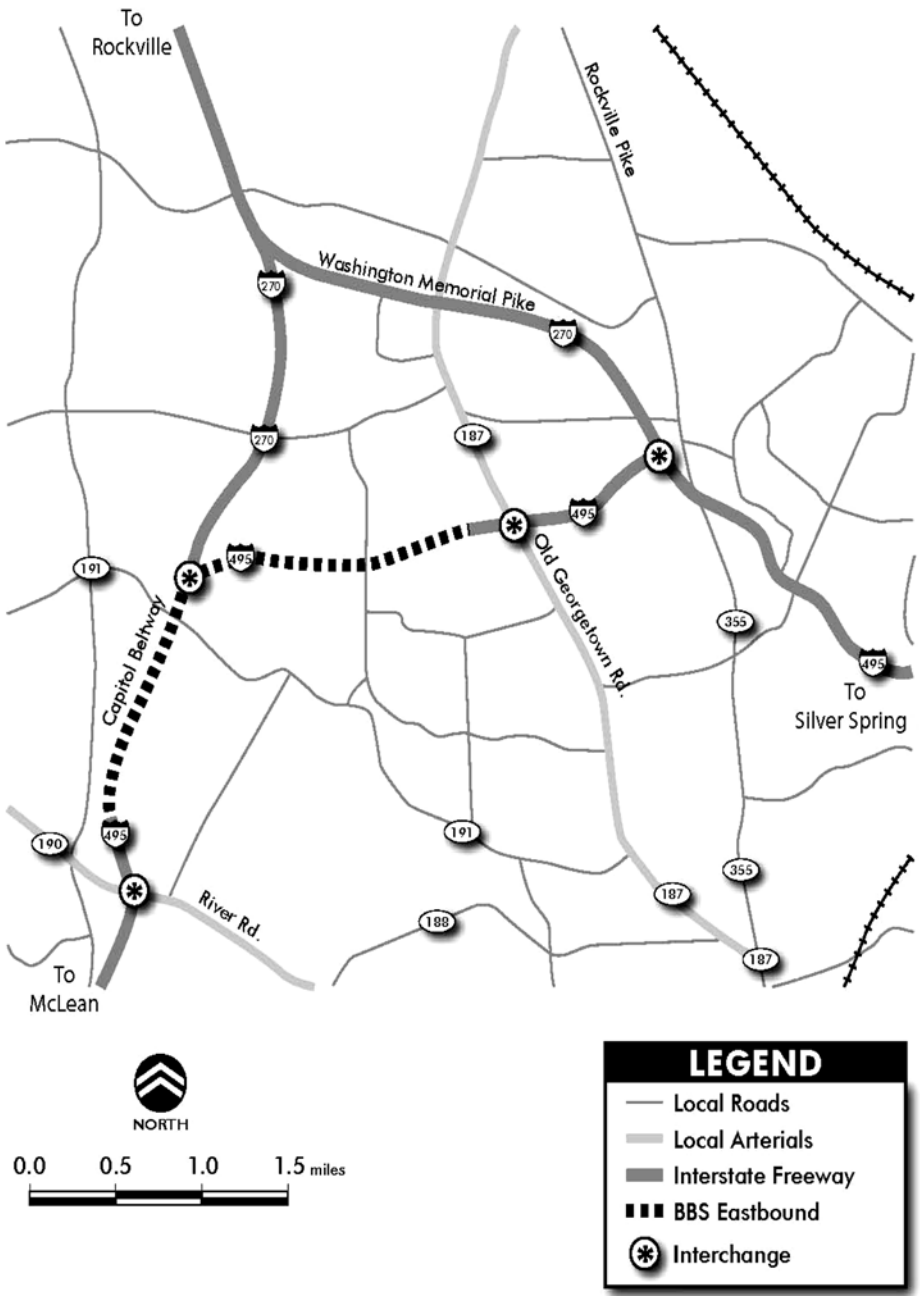


FIGURE 3 Maryland I-495 BBS location.

Washington, Seattle Area

Two bus shoulder use projects are currently in operation in the Seattle area. The first, a 2.7-mi westbound BBS segment of SR-520 from I-405 to the Evergreen Bridge, allows buses and 3+ HOVs to use the freeway shoulder lane to bypass congestion. SR-520 is basically a 60-mph posted-speed limit, four-lane freeway connecting Bellevue to Seattle. Buses and HOVs are allowed to operate at the posted speed while using the shoulder. This BBS was originally opened in 1970 as a toll booth bypass and it was later converted to its current HOV 3+ usage. The shoulder is 13 to 14 ft wide along this section of SR-520. Shoulders are marked with a solid white line separating them from general traffic lanes and HOV diamond markings are provided (see Figure 8). Wayside HOV diamond lane traffic signs also identify the special use lane. Only limited physical improvements were made to the shoulders to implement the BBS. HOV drivers and buses must weave with exiting traffic at interchanges and again with entering traffic at on-ramps. Figure 9 describes signage and lane marking guidelines for interchange areas. Motorists with automobile troubles are encouraged to exit the freeway rather than use the shoulders, and tow trucks are strategically stationed to remove disabled vehicles from shoulders and

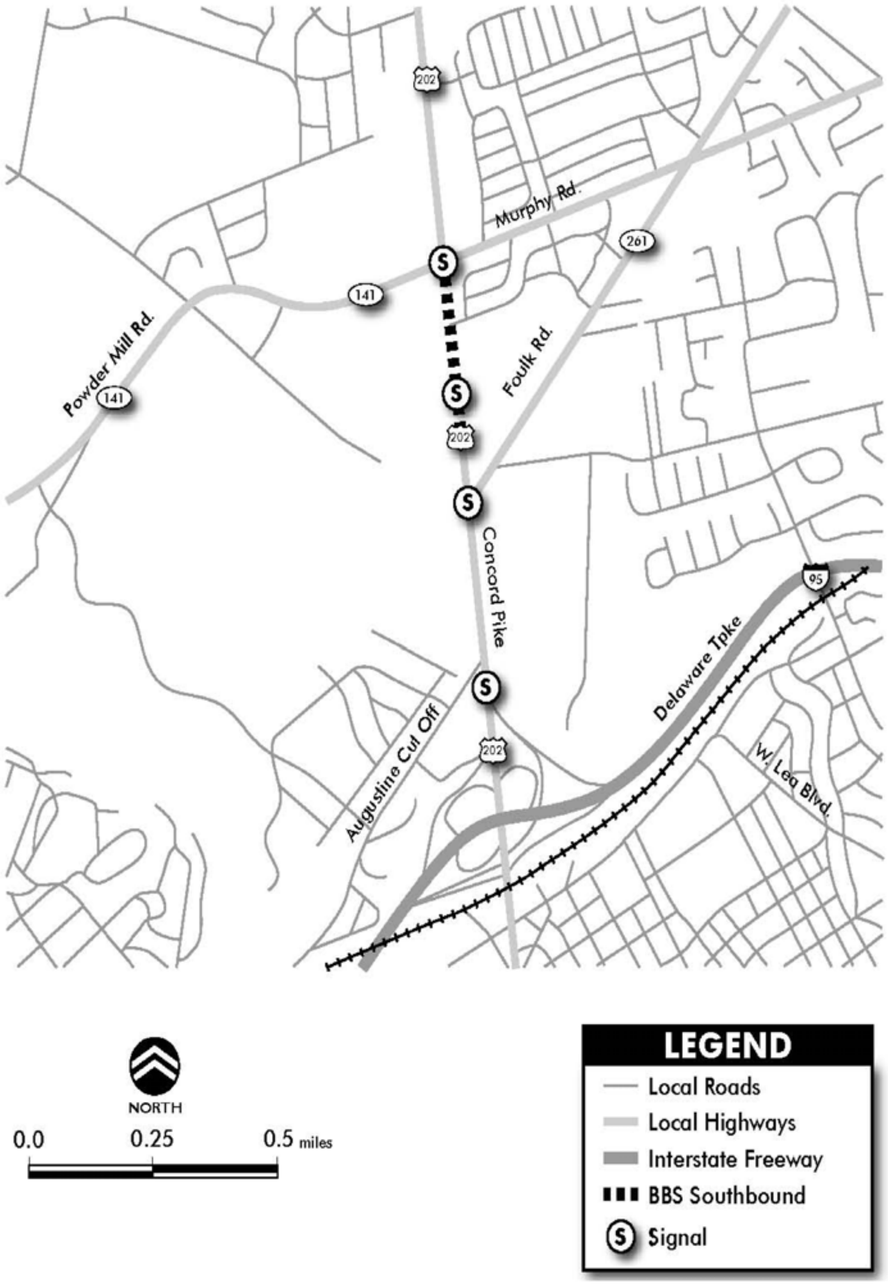


FIGURE 4 Southbound US-202 BBS, north of Wilmington, Delaware.

traffic lanes of SR-520. Overall, motorist compliance has been good as has the safety record.

The second BBS project is on SR-522, a five-lane major arterial highway serving the northern suburbs of Seattle. For both directions of travel on a 2.2-mi segment of SR-522 (NE Bothel Way) between NE 165th Street and 73rd Avenue NE (Kenmore, Washington) the shoulder lanes are restricted for bus use only. The westbound BBS opened in 1970 and the eastbound BBS in 1986. The shoulder pavement is marked with "Only Transit" (see Figure 10) and "Transit Only" signs are intermittently placed along the route. On SR-522, the BBS allows buses to queue jump congestion at traffic signals. Some conflicts have been reported with bicycles on the SR-522 shoulders.

Both of these BBS operations in the Seattle area are full-time operations. Special speed restrictions are not posted for the shoulder lane operations, allowing buses to operate at the full posted speeds. Travel time and reliability performance has been good on both BBS projects. An advantage of the BBS operations as seen by bus operators is that they eliminate the weaving movements across general traffic lanes to enter and exit center median HOV lanes. In addition,

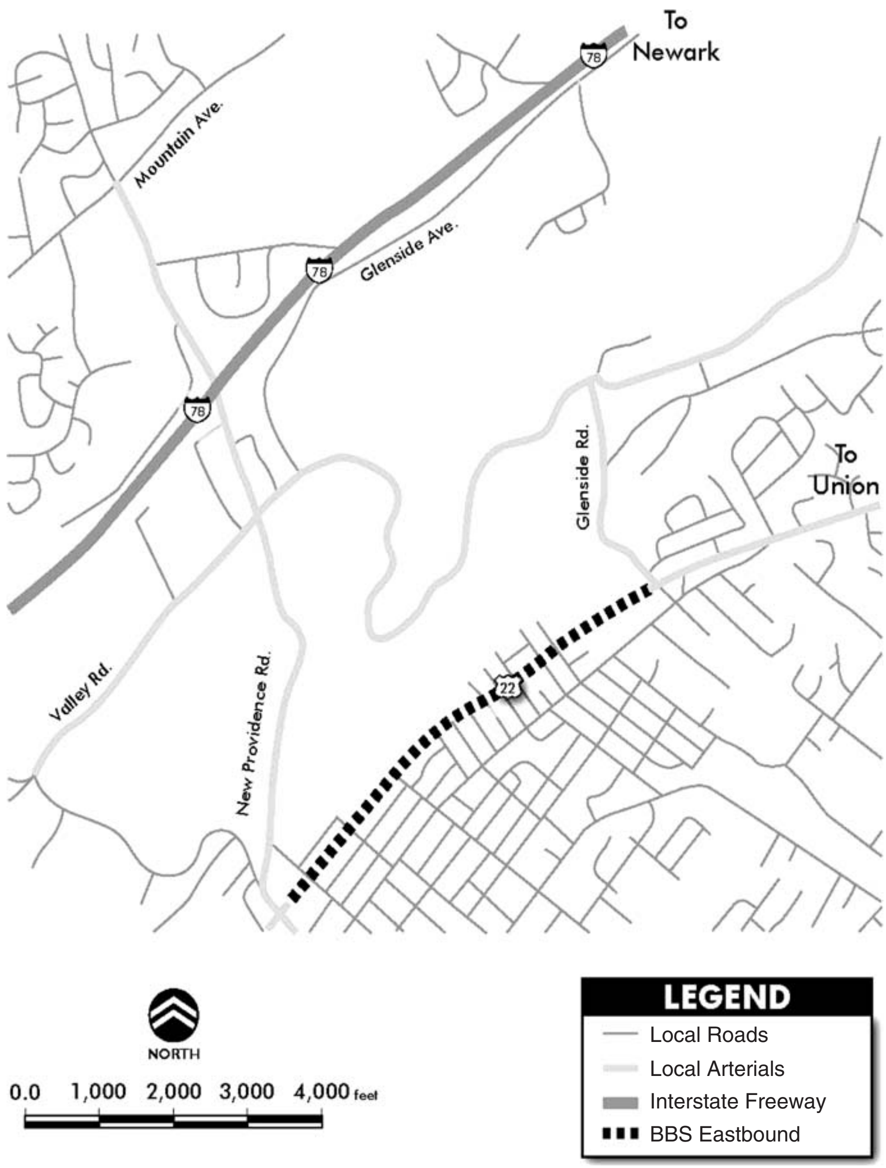


FIGURE 5 New Jersey Route 22 Mountainside eastbound BBS.

the shoulders offer opportunities to serve passengers with on-line freeway bus stops along the corridor.

The Washington State DOT also has about a dozen on-ramps where buses and HOVs are allowed to use shoulder lanes through interchange areas to bypass congestion. These interchange applications are limited to commute periods when ramp metering is operational.

Miami, Florida

The Miami–Dade MPO completed a Special Use Lane Study for the region in 2005 that addressed BBS projects patterned after the Minneapolis program. The Special Use Lane Study recommended further analysis of an Express Core System that would consist of buses using shoulders on the Homestead Extension of Florida's Turnpike, SR-826 (Palmetto Expressway), and SR-836 (Dolphin Expressway). Subsequent discussions reportedly have expanded this feasibility analysis to consider bus shoulder use on I-95 from SR-112 to downtown Miami. The work scope for the further studies is provided in Appendix C, which also lists key concerns raised by agencies participating in the study.

Agreements between Miami–Dade Transit, the Miami–Dade Expressway Authority, and the Florida DOT have been executed. Actual operation is anticipated for May or June 2006. The first BBS express service will be on the Dolphin Expressway from NW 107th Avenue to downtown Miami. Operations on the Don Shula Expressway and the Snapper Creek Expressway should follow shortly.

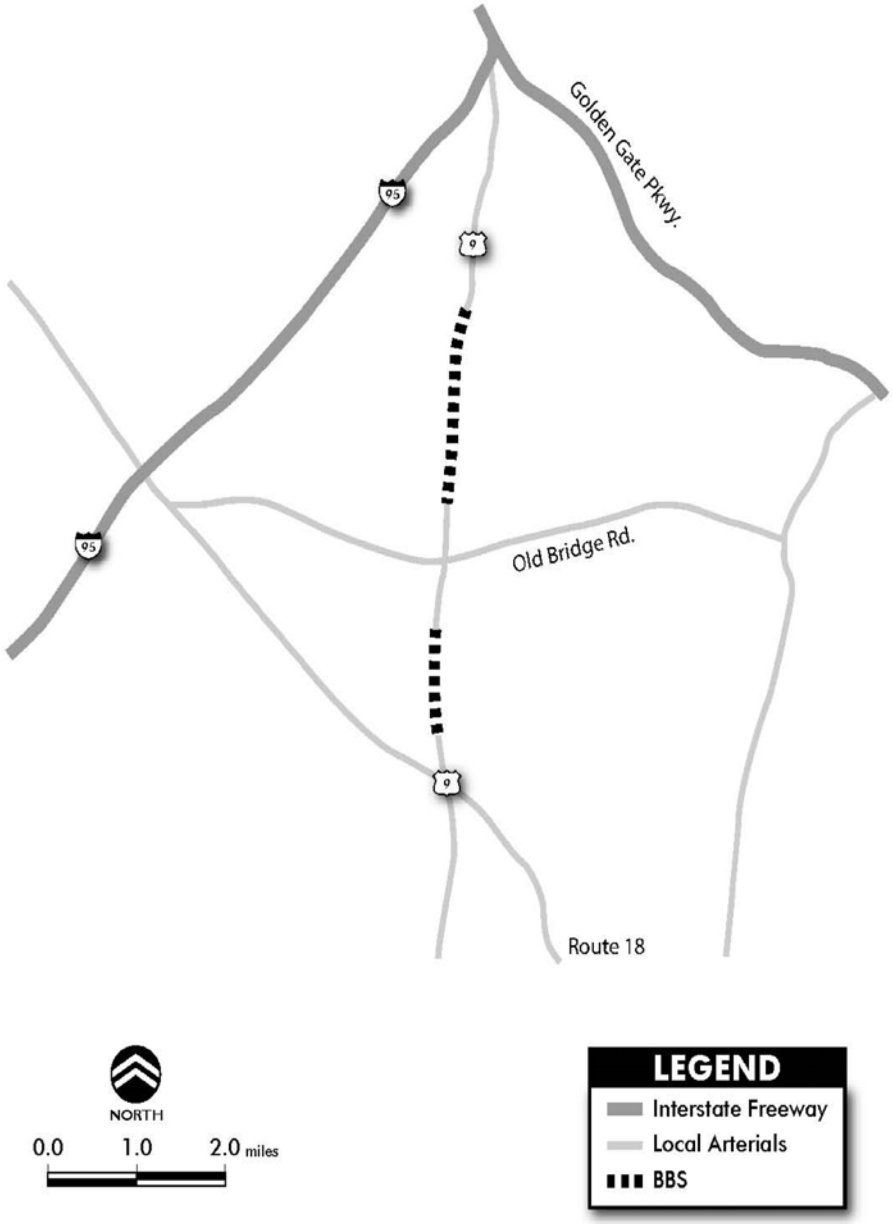


FIGURE 6 New Jersey Route 9 BBS in Middlesex County, New Jersey.

Future BBS projects under study include a section of the Homestead Turnpike extension project (Homewood Extension of Florida's Turnpike) extends from the Turnpike interchange with I-75 to Homestead; however, the shoulder use concept is being considered from SR-836 (Dolphin Expressway) to Kendall Drive (SW 88th Street). The Palmetto Expressway is a major north–south wide urban expressway serving the western and northern edges of Miami. The Dolphin Expressway links Miami's downtown to the Miami International Airport and also to the Miami Dolphin football stadium. At I-95, the Dolphin Expressway becomes I-395.

The bus use of shoulders concept that is currently under study is envisioned to limit bus speeds to a maximum of 35 mph when using the shoulder. Only public buses traveling in the peak direction of travel would be allowed to use the shoulders, and special training would be given to bus drivers. The training program is currently under development by Miami–Dade Transit.

Legislation is now pending to allow the bus use of shoulder facilities and the projects are anticipated to be implemented late in 2005. A marketing program is envisioned to educate motorists about of the program and an enforcement program is under development.

Details of ITS features of the bus shoulder use program are still under development, but are expected to include transponders on buses to allow them to use the SunPass lanes at toll plazas.

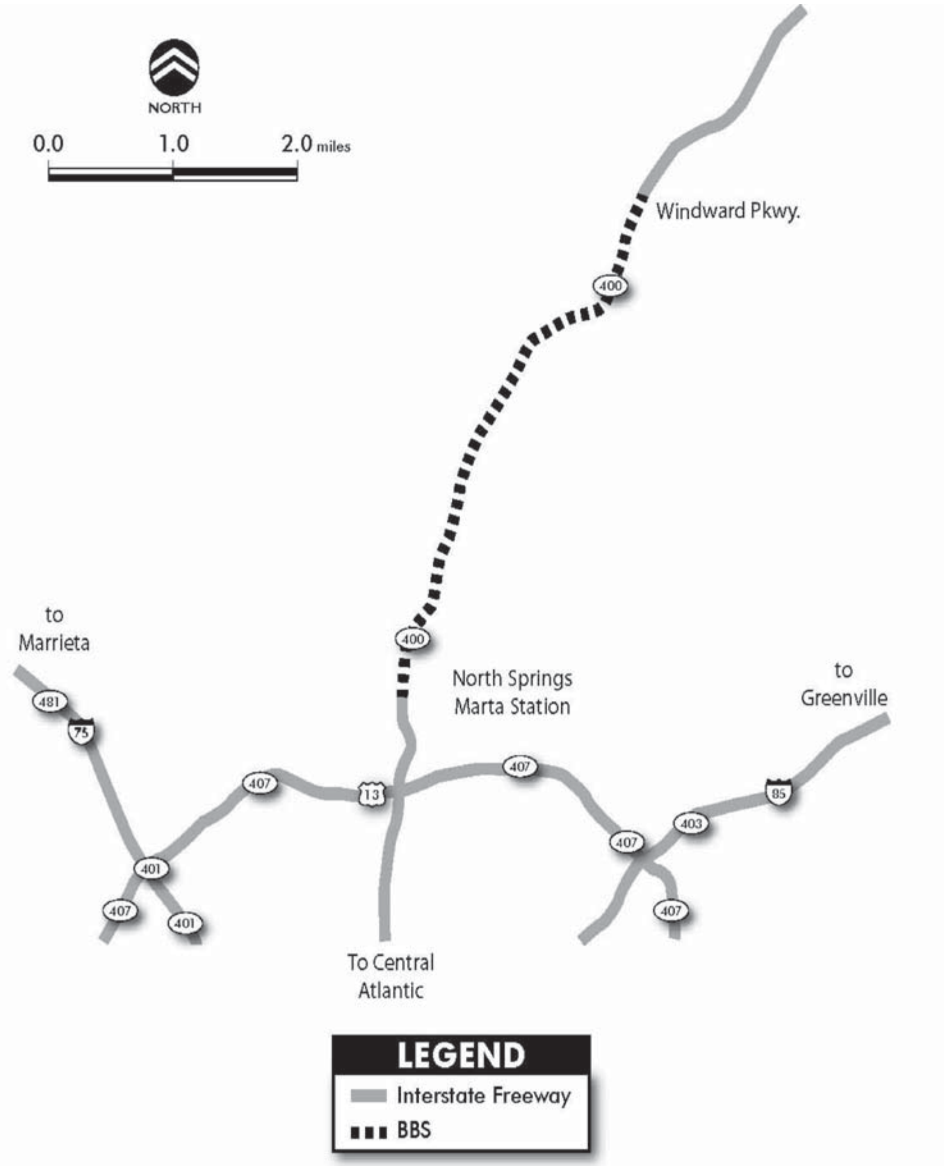


FIGURE 7 Georgia Route 400 BBS location.

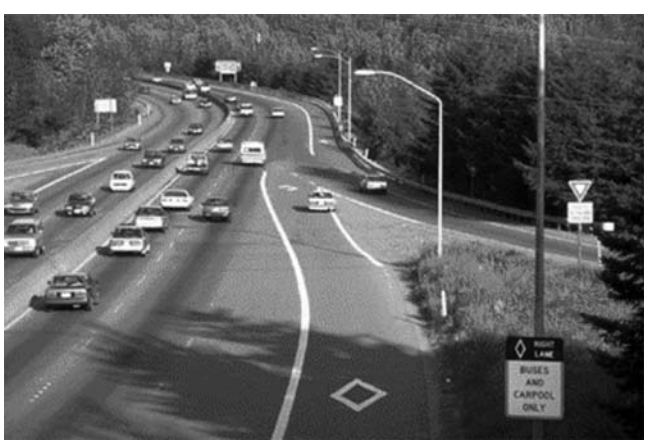


FIGURE 8 Washington State DOT SR-520 BBS on-ramp diamond weave markings.

San Diego, California

Initially the pilot BBS concept was considered for I-15. Current plans are to operate a 1-year pilot project on I-805 and State Highway 52 between Kearney Mesa and University City. The California DOT (Caltrans) has assumed the lead for this project, which opened in December 2005. Caltrans led the preparation of the signage and striping plans and processing National Environmental Policy Act 1989 environmental clearance for the project, and the MPO and transit operator developed the bus operating plan and a training program for bus drivers. It is understood that in some places the travel lanes were restriped to provide 10-ft minimum shoulder widths. Messages ("Freeway Shoulders for Buses Only") are posted on the back of buses. Case Study 4 provides more details on this BBS project.

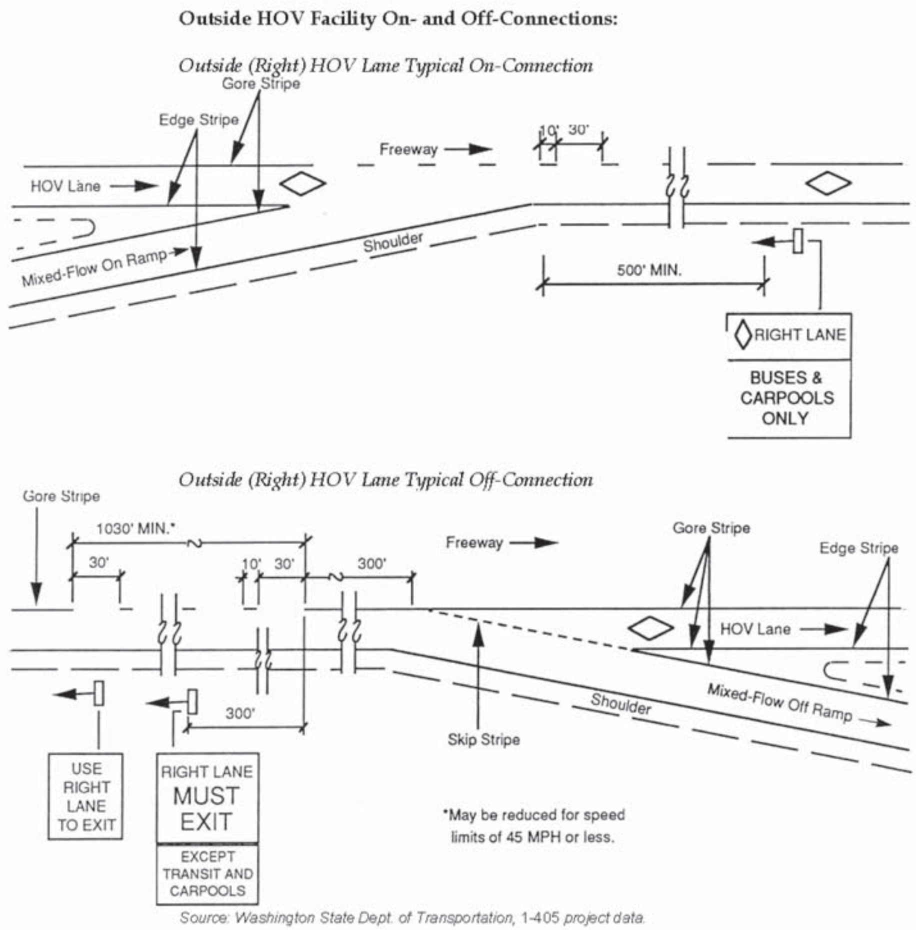


FIGURE 9 Washington State DOT BBS interchange signage and striping.

Ottawa, Ontario

Ottawa operates 14 mi of bus use of shoulders on limited access facilities. Only public transit buses are allowed to use the shoulder lanes. No special speed restrictions are defined and buses are allowed to operate up to the posted speed at their discretion. The buses normally get on and off at most interchanges to make station stops and the BBS operation helps to minimize conflicts with traffic at the ramps. Figure 11 portrays Ottawa's station stopping concept. Additional shoulder facilities have been developed on some segments to accommodate disabled vehicles.

FIGURE 10 Washington State DOT SR-522 BBS pavement markings.

Buses using shoulder lanes are allowed to operate at speeds of up to 100 kph (62 mph). Therefore, buses can operate at substantially higher speeds during periods of congestion than vehicles in the adjacent general purpose traffic lanes. Figure 12 describes two cross-section plans for bus use on shoulders in Ottawa. Regional Road 174 was opened for shoulder bus use in 1992 and has a 5 m (16.4 ft) width to edge of pavement. A 2% cross slope is allowed. Regional Road 417's bus use of shoulders operation is more recent. Its shoulder cross section spans 7 m (23.0 ft) and includes a 3.5 m bus shoulder, plus a 1 m shoulder and 1 m refuge edge area. The adjacent general purpose lane is 3.75 m (12.3 ft). The Ottawa experience suggests that where an emergency shoulder can be provided adjacent to the bus shoulder it is desirable, but not essential. Again, these shoulder cross sections allow for buses to operate at speeds of up to 62 mph.

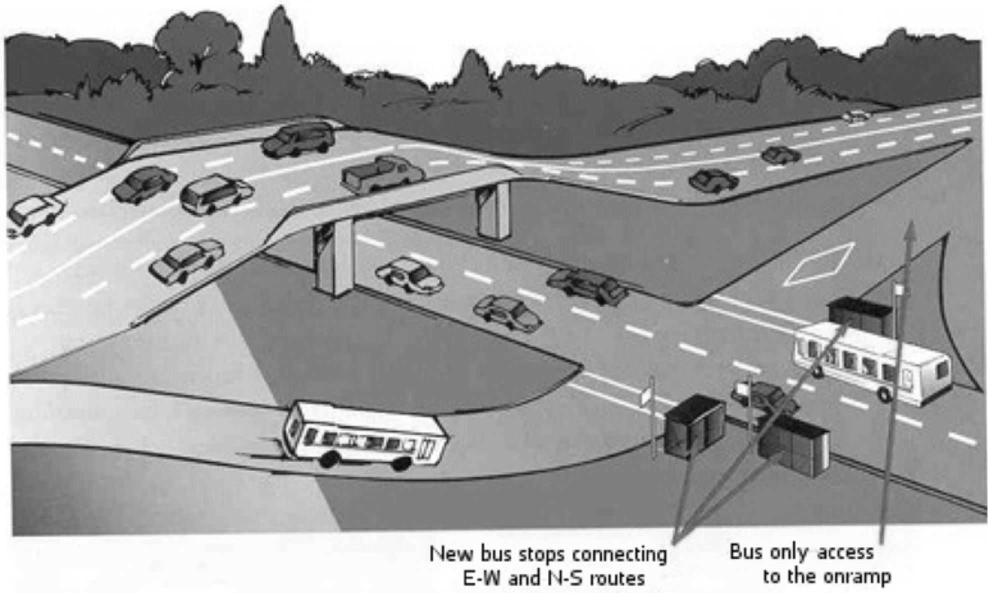


FIGURE 11 Ottawa Bus station stopping concept.

Bus volumes are relatively high (100 buses per hour) and this constant use of the shoulder might help to minimize surprises to motorists in the adjacent general purpose lane.

Toronto, Ontario

GO Transit has implemented a bus use of shoulders project for Highway-403 between Erin Mills Parkway and Mavis Road. Buses are permitted to use the shoulder when speeds drop below 38 mph, and are instructed to go no more than 12 mph faster than traffic using the general traffic lanes. The shoulder is 12.3 ft wide in both the eastbound and westbound directions. The presentation used to train bus drivers on the use of the shoulder lane is provided in Appendix C (C6). Additional information on the Highway-403 BBS is provided in Case Study 5.

Vancouver, British Columbia

The British Columbia Northbound Route 1 approach to the Ironworkers Memorial Bridge (Highway 1) into Vancouver has a BBS queue jumper. This application functions similar to a long queue jumper.

Dublin, Ireland

The Ministry of Transport and Eireann Bus operate BBS projects on dual carriageways connecting Dublin to satellite towns. BBS projects include the N2, N3, N4, N6, N8, and N11. Some of the BBS projects have adjacent bicycle lanes. Case Study 6 provides details.

Auckland, New Zealand

The Auckland, New Zealand, Bus Priority Initiatives 2003 program identifies a number of shoulder use applications for its Northern Motorway, Northwest Motorway, and Southern Motorway. These were implemented from 1997 through 2002. BBS has been implemented in several of Auckland's major travel corridors, none of which are located in the center city core. The longest BBS projects are located on the north and west sides of Waitemate Harbor. The Northern Motorway projects extend from just across Waitemate Harbor from Auckland to Takapuna and the Northwest Motorway BBS serves the area toward Massey West. A short section of BBS was implemented on the Southern Motorway. The Auckland Regional Transport Authority considers its BBS projects to be one of their success stories and is interested in setting up other BBS sites.

Northern Motorway BBS

- Tristan Avenue to Exmouth Road a.m. peak shoulder lane (pre-1996 implementation)—travel time savings reported as "high."
- Constellation Drive to Tristan Avenue a.m. peak BBS (1997)—travel time savings reported to be "high."
- Northcote Road Interchange a.m. peak BBS (2000)—travel time savings reported to be "moderate."
- Esconde Road Interchange a.m. peak BBS (2000)—travel time savings reported as "minor."
- Esconde Road to Onewa Road a.m. peak BBS (2000)—travel time savings reported as "minor."
- Greville Road to Constellation Drive BBS extended to p.m. peak.

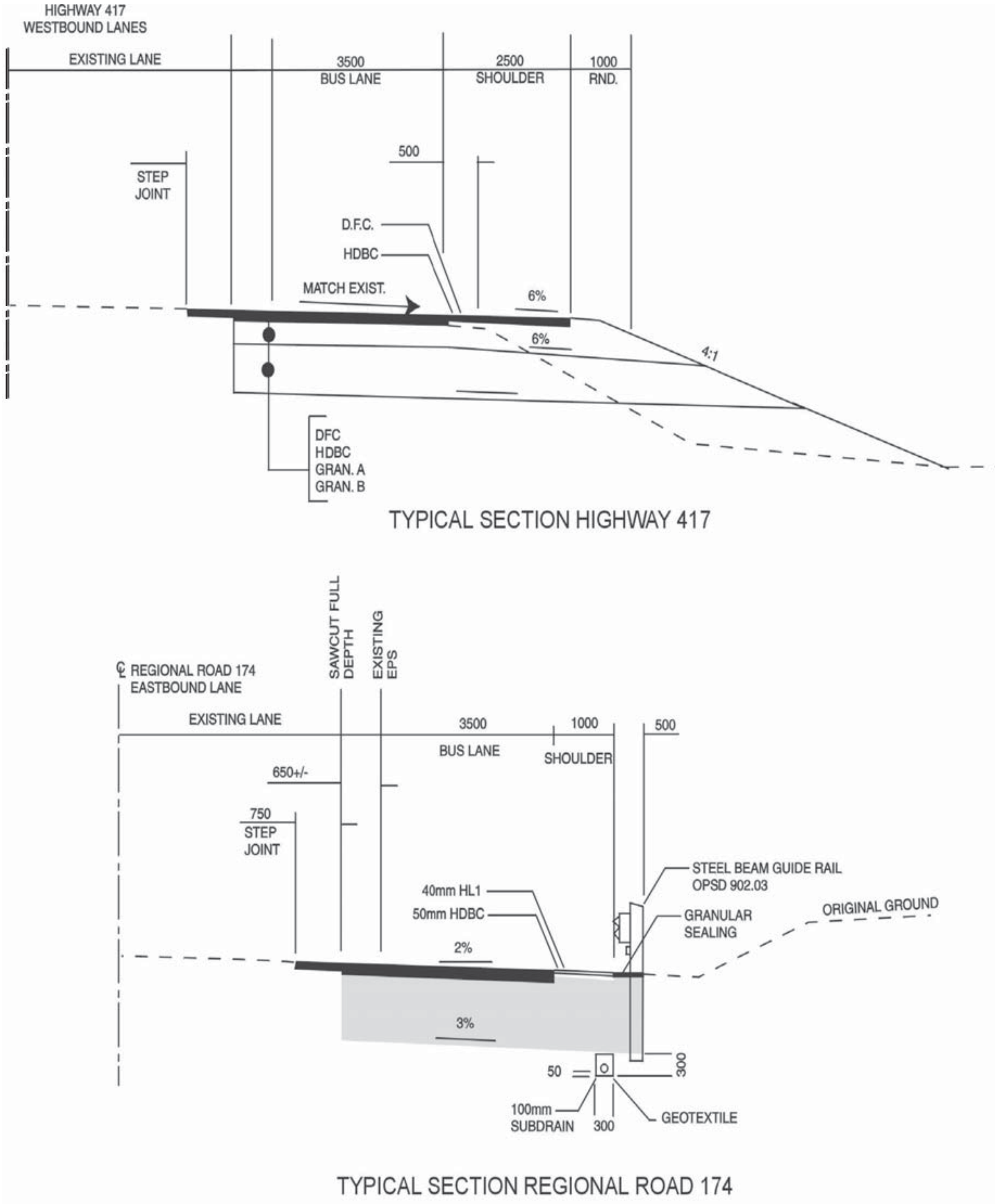


FIGURE 12 Typical shoulder bus lane sections in Ottawa. (*Source*: John Bonsall, McCormick Rankin International.)

- St. Marys Bay BBS extended eastward to start at Fanshawe off-ramp (2001)—travel time savings reported to be "moderate."

Northwest Motorway BBS

- Lincoln Road to Patiki Road a.m. peak BBS segments (1996)—travel time savings reported to be "high."
- Patiki Road to Rosebank Road a.m. peak BBS (2001)—travel time savings reported as "high."

Southern Motorway BBS

- Mt. Wellington to Ellerslis/Penrose a.m. peak BBS (1999)—travel time savings reported to be "high."

BBS operations were implemented in June 2005 along a 0.9 mi extension of the Northwest Motorway between Great North Road and Rosebank Road. The shoulder improvements cost approximately $1 million.

The BBS projects in Auckland generally require buses to merge into general traffic at interchanges. The BBS lanes generally start at the off "nose" and end before the off-ramp gore point. Buses use the BBS through the on-ramp merge area. This practice has reportedly worked well, because the buses are all large (visible) and on-ramp traffic is aware that the buses will not be competing for space in the general traffic lanes once past the interchange.

The minimum shoulder width for BBS operations is 3.0 m (10 ft). Buses are allowed to operate at safe speeds of up to 70 kph (44 mph).

BUS USE OF SHOULDER CONCERNS

Survey respondents were asked what types of concerns they have regarding the design, operation, and implementation of the bus use of shoulders concept. The following types of concerns were expressed.

Loss of Intended Shoulder Functions

Shoulders provide a range of important functions. Use of the shoulder by buses at times when the highway is congested and moving slowly compromises these functions, even if shoulders are limited to bus use only. Four shoulder use functions were identified as concerns by survey respondents.

- Removal and storage of disabled vehicles and accidents,
- Emergency vehicle use,
- Staging area for maintenance work, and
- Snow storage.

It was pointed out that highways tended to be most congested when accidents have occurred, when disabled vehicles are being attended to along the roadside, when highway maintenance work was ongoing, and when weather conditions are poor (e.g., when it snows). Accident situations also are the times when emergency vehicles most need to use shoulder facilities.

Some of these functional concerns seem to be based on the perception that high volumes of vehicles would use the shoulder and the shoulder itself would become congested. If shoulder use is restricted to bus traffic only and bus drivers were in close radio communications with central dispatch, most of the shoulder use concerns could be effectively addressed. Because no physical barriers would be constructed between the shoulder lane and the right-most general traffic lane, buses could merge into general traffic lanes to bypass obstructions along the shoulder. Advisories to bus drivers could also address the maintenance staging and snow storage concerns. Loss of intended shoulder functions has not proven to be a problem at established BBS sites.

Traffic Safety

The most common concerns that were raised by survey respondents dealt with traffic safety. Eleven types of traffic safety concerns were identified.

- Conflicts at on- and off-ramps;
- Sight distance adequacy, particularly at on-ramps;
- Conflicts for motorists pulling onto the shoulder;
- Loss of safe evasive movement shelter area;
- Need for bus driver training;
- Speed differential;
- Impact on adjacent lane motorists;
- Return merge distance adequacy;
- Shoulder area debris hazards;
- Reduced clearance for buses at bridge abutments; and
- Drainage and hydroplaning.

The first five of these safety concerns relate to potential traffic conflicts along the shoulder lane. Motorists exiting from the general traffic lane will not be expecting a bus approaching from behind using the shoulder. Motorists needing to pull onto the shoulder similarly will not be expecting traffic using the shoulder. Most motorists pulling onto the shoulder use their turn signals, which would warn buses using the shoulder as well as motorists that are following in general traffic lanes. Traffic entering the highway will not expect traffic using the shoulder lane and typically will have shorter merging sight distances. On occasion, motorists use shoulders to evade collisions and abrupt changes in traffic speeds. If buses are using the shoulder lane, this evasion option could be compromised. Establishment of good operating protocols, training of bus drivers, and good signage can help minimize these safety issues, but the more intense use of the highway right-of-way will inherently increase traffic safety risks. By limiting use of the shoulders to conditions when general traffic is operating slowly and limiting the speeds of buses using the shoulder facilities, the risks are more manageable.

The next three of the safety concerns relate to potential impacts on traffic using the general traffic lanes. Unexpected traffic traveling at high speed in the shoulder lane could surprise some motorists and lead to accidents. If the development of shoulder use lanes involves narrowing general traffic lanes to provide a wide shoulder, the narrowed general traffic lanes will likely lead to increased accident risks (particularly at periods of high speed when the shoulder is not being used). The importance of safe design to accommodate the transition from shoulder to general traffic lanes was also identified as a concern. With the exception of the narrowing of general traffic lanes, these safety concerns all appear manageable using good design and operations practices.

The last three of the traffic safety concerns identified by survey respondents relate to obstructions and physical features.

- Regular use of the shoulders probably would require increased efforts to remove debris from the shoulder area.
- Operations of wide vehicles on the shoulder also reduces the horizontal clearance between moving traffic and bridge abutments, railings, sign posts, and other lateral obstructions.
- Drainage failures most often affect shoulder facilities rather than high-speed general traffic lanes. One respondent felt that this would increase hydroplaning risks.

Good bus driver training, good operating protocols, and careful design would appear to address most of these issues.

Physical Design

Design practices and operating environments vary by jurisdiction. Seven concerns were identified for physical design.

- Shoulder width adequacy,
- Shoulder pavement strength,
- Signage needs,
- Lateral obstruction adjacent to shoulder,
- Need to narrow general traffic lanes,
- Modifications to drainage inlets compromise function, and
- Conflicts with pavement edge rumble strips.

Shoulders generally have not been constructed to accommodate regular use by large vehicles. Most modern shoulders are 10 to 12 ft wide; however, many older highways have narrower shoulders and less clearance to lateral obstructions. Buses are 8.5 ft wide excluding mirrors and approximately 10 ft wide with mirrors. Shoulder pavement typically is not designed to the same thickness and strength as general traffic lane pavement. Conventional traffic signage is not designed to support shoulder use operations. Drainage inlets along shoulders are not designed for comfortable traverse by buses and reconstruction can compromise their ability to effectively remove water from the roadway. Electrical junction boxes also often need to be relocated. Lastly, some highways are designed with rumble strip warning edges between the general travel way and the shoulder. These rumble strips would not support comfortable use of the shoulder and would need to be removed. An issue that was not identified from the project survey, but is also important concerns drainage cross slopes. Shoulders typically have cross slopes greater than general traffic lanes and the higher cross slopes increase the level of discomfort for bus passengers. These are all important design considerations; however, they can generally be addressed by physical upgrades to the highway facility. The costs for these upgrades vary widely, but are modest compared with most highway widening and interchange reconstruction costs.

Legal

Codes in most states do not allow vehicles to use shoulder lanes for congestion bypass purposes and without enforcement abuses are inevitable. Concerns related to this are regulatory authority and enforcement of abuses.

The implementation of bus use shoulders needs to include a framework and facilities to enforce regulations. As most abuses would typically include cheating by exiting and entering motorists, rather than continuous travel by general traffic on the shoulder, clear boundaries need to be defined for the exit and merge interchange movements.

Costs

In addition to the cost needed to upgrade shoulders to allow for bus use, concerns were also raised about the added cost of maintenance necessary to keep shoulders free from debris and to maintain the shoulder pavement.

Special issues that were raised for toll road facilities included the acceptance of toll paying motorists for the preferential use of the shoulders and also how to handle the shoulder use at toll plazas.

OPERATIONAL EXPERIENCE

Safety

A 1998 study of the Minneapolis bus shoulder use found:

1. Travel time savings are quite variable and depend greatly on weather and traffic conditions. The worse the weather and traffic, the greater the time savings. During snowy conditions, the 4-mi I-35 segment between Lake Street and Highway 62 (the Cross-town) realized a 9-min travel time savings using the shoulder.
2. Bus-only shoulder operations are inherently safe; from February 1996 to June 1996 there were only three crashes, none of them serious.
3. A 10-ft-wide shoulder is marginally adequate. Drivers are uncomfortable with the narrow lanes, especially during adverse weather conditions (and adverse weather conditions are where travel time savings are the greatest). Snow and other debris that obstruct visibility add to the discomfort level.

NCHRP Report 369: Use of Shoulder and Narrow Lanes to Increase Freeway Capacity (*3*) provides the most extensive analysis of narrowing lanes to use shoulder facilities *for general traffic*. This study did not address the more controlled concept of allowing only buses to use the shoulder lanes. *NCHRP Report 369* cautions against using the right shoulder, particularly for segments with high truck volumes. It found that accident rates increase for shoulder use application when the shoulders are less than 12 ft wide. The accident rate increase was greatest for the first 2 years (up to a 60% increase) and tended to level off at 10% to 15% higher than unaltered conditions after the first 2 years.

INTELLIGENT TRANSPORTATION SYSTEMS

The potential benefits of driver assistive technology are currently being researched by the University of Minnesota. Their research is aimed specifically at making it easier and safer for Metro bus drivers to operate on narrow shoulder lanes. The research is addressing virtual mirror and virtual bumper systems, as well as the lane keeping assist concept. It is a global positioning system-based approach. Magnets embedded in the roadway pavement are another technology approach that is under development for the lane keeping assist concept. Other ITS technologies of potential application for BBS lane use include incident monitoring systems and variable message signs. Virginia's DOT currently uses overhead message signs to advise motorists on I-66 as to when shoulder lanes are open for general purpose traffic use (see Figure 13). Incident monitoring systems could alert bus drivers to shoulder lane blockages and also to mainline freeway travel speeds. The latter could provide a consistent definition for buses shifting to shoulder use running. ITS signage could alert motorists to shoulder bus operations.

FIGURE 13 I-66 shoulder lane use control sign and signal (Fairfax County, Virginia).

CHAPTER THREE

CASE STUDIES

This chapter presents six case studies: Minneapolis–St. Paul; Falls Church, Virginia; Miami, Florida; San Diego, California; Toronto, Ontario, Canada; and Dublin, Ireland.

CASE STUDY 1—MINNEAPOLIS–ST. PAUL TWIN CITIES

The Minneapolis–St. Paul Twin Cities area first established BBS operations in 1991 on a six-lane arterial highway (Highway 252). In rapid response to a 1992 flood closure of some major highways, the BBS operations were expanded to the freeway system as well as to several other key highways. The BBS network has continually expanded and today consists of 230 mi of shoulders for authorized bus use. Figure 14 summarizes the comprehensiveness of the current BBS network. Figures 15 and 16 present the annual miles of bus shoulder use facilities added to the network annually since 1992 and the cumulative total network miles of bus shoulder use facilities.

History

The use of shoulder lanes for transit in the Twin Cities area evolved out of an emergency situation, when a 1992 Mother's Day flood closed one of the major bridges that crossed I-35 westbound. This bridge was one of the major access points into and out of the city. The governor formed a team of Minnesota DOT (MnDOT) and Minnesota Transit officials to brainstorm on how to get more access on parallel bridges. The use of shoulder lanes by transit vehicles emerged as an idea worth implementing. The concept was approved late one week and by early the following week the shoulder lanes were restriped and limited signage was in place for transit to begin operations.

This first test of buses in the shoulder lanes went so smoothly that they began testing operations on other congested freeway segments. Team Transit was then formed as a permanent group, consisting of Metro Transit and suburban bus operators, MnDOT, Minnesota State Patrol, and the Metro Council of Governments. The Deputy Commissioner of MnDOT helped overcome potential problems with lower level staff bureaucracy by establishing a key contact person at MnDOT, who serves as an advocate for the shoulder lane policy within the agency. To this day, the Team Transit group has continued to periodically review existing operations and plan additional shoulder lane projects. The result is that currently there are 14 routes and 400 buses that use the freeway shoulder lanes on a daily basis. Four of the major Interstates are equipped with more than 200 mi of freeway shoulders used as transit routes.

For the first 5 years of the program, MnDOT and Metro Transit split the costs of shoulder lane projects; Metro Transit found that if they brought funding to the table, MnDOT was more receptive to constructing a project. After the shoulder lanes became "just another part of the highway system," MnDOT established an annual budget of $2 million for the program, which adds approximately 20 mi to the system annually. It is part of the overall annual budget and MnDOT works with Metro Transit to prioritize the funds. A construction figure of $100,000 per mile was quoted as the good overall cost to use for upgrading shoulder lanes, including the rebuilding of drainage grates and paving at a 3- to 5-in. asphalt depth.

As the transit use of shoulder lanes became a permanent feature of the freeway system, much of the day-to-day efforts evolved into discussions of planning and implementation of new shoulder lanes for transit. Rather than being stand-alone improvements, the shoulder lane projects (whether it be widening, reconstruction, or restriping) are completed as part of a larger highway improvement and maintenance project along that same freeway segment. Interestingly, the Minnesota State Patrol has not been actively involved in recent years owing to safe operating experience (they do have the ability to report or cite transit vehicles that violate the shoulder lane policy).

Maintenance of the shoulder lanes is handled by MnDOT, which has a $1 million line item in its budget specifically for shoulder lane maintenance. Metro Transit benefits through federal 5307 capital guideway maintenance funding based on a payment of $30,000 per shoulder lane mile (as shown in Section 15 reporting), which results in approximately $6 million annually that they reserve to supplement their operations.

There are little to no public relations efforts related to the shoulder lane program—officials believe that it has not been necessary.

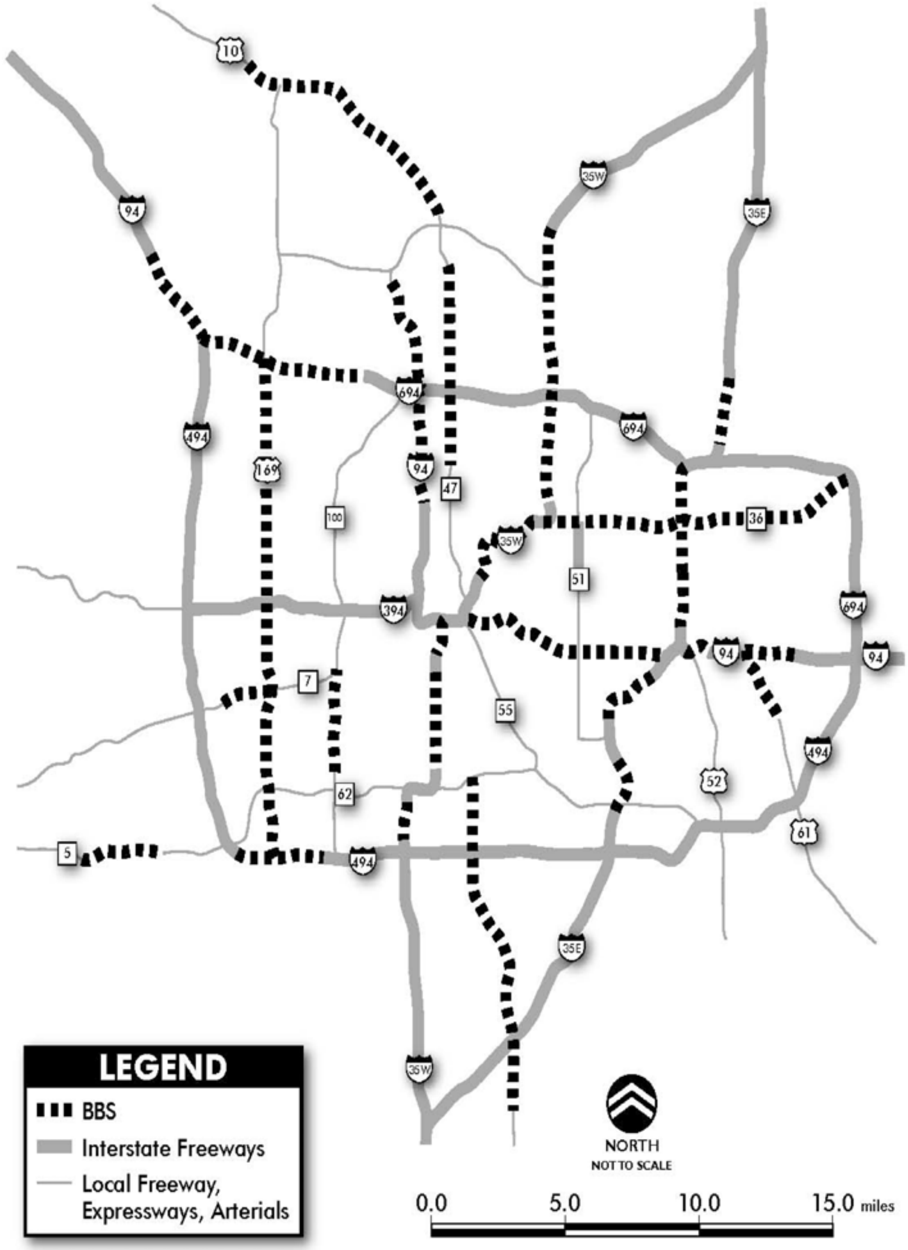


FIGURE 14 BBS network—Twin Cities area.

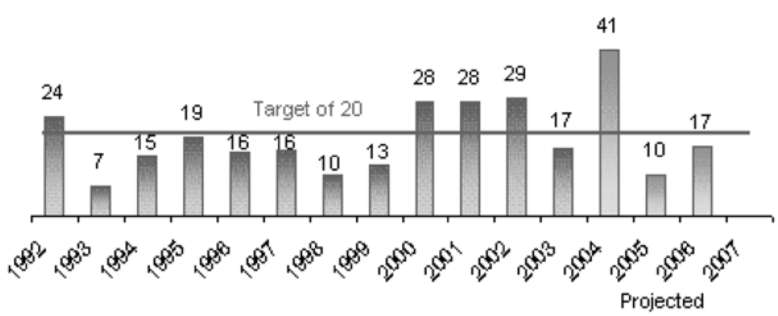


FIGURE 15 Bus shoulder miles built or rebuilt annually.

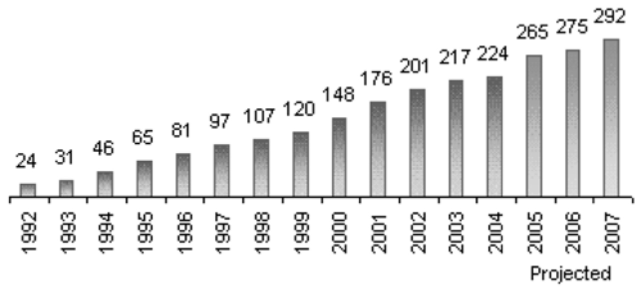


FIGURE 16 Total bus shoulder miles in Twin Cities metro area.

Operations

Below are some highlights of transit operations of freeway shoulder lanes:

- Bus drivers use the shoulders only when general purpose lane (GPL) travel speeds drop below 35 mph. Buses travel only 15 mph faster than mainline traffic, up to a maximum of 35 mph. If traffic is moving 35 mph or faster, buses must operate in the regular traffic lanes. Transit drivers are not required to use shoulders, but instead use their professional discretion on roadway conditions and personal comfort levels.
- If a disabled vehicle blocks the shoulder lane, or the highway patrol has pulled a vehicle over in the shoulder lane, the transit vehicle merges into the GPLs to bypass the obstruction. Because the speeds are low for automobiles in the GPLs and the bus in the shoulder lane, the merge is a relatively easy maneuver for the transit vehicle.
- Metro Transit occasionally does field checks to monitor whether drivers are exceeding the speed limit or operating in areas not a part of the shoulder lane system. Violations of the operating procedures are rare. The Minnesota Highway Patrol is now able to stop and ticket a bus operator; however, this has not yet happened.
- Initially, there were some copycat drivers who followed the buses into the shoulder lanes; however, this has not been a problem for some time.
- The freeway signage is minimal. There are signs on freeway on-ramps to alert drivers to watch for buses on the shoulders and the occasional sign between interchanges that designate the shoulders for use by buses.
- Signage also designates the beginning and end points of bus shoulder lane operations.
- Among the 200 mi of shoulder lanes, several occur on arterial highways. At signalized intersections, a "porkchop" raised curb section allows cars a free right turn with sufficient length along the raised curb to serve as a bus queue jump to the front of the signal and as the location for a bus stop.
- On bridges, the 10-ft shoulder width is acceptable if the bridge length is relatively short (e.g., an overpass). For longer bridges, Metro Transit requires an 11.5-ft shoulder width given the difficulty of driving adjacent to the bridge railing. In these cases, MnDOT has been agreeable to taking 6 in. from the adjacent travel lanes to create the extra space in the shoulder.
- Bus drivers were initially uncertain about operating in the shoulder lanes and would generally operate at slow speeds. However, speeds increased with experience.
- There are gaps in the shoulder lane sections at locations where bridge abutments are directly adjacent to the shoulder lanes, narrowing the shoulder to less than 10 ft. The sections are noted on the listing of shoulder lane sections given to bus drivers. A small sign is also located before the narrowed section to alert the driver, who simply merges into the main travel lanes to avoid the narrow section, and then merges back into the shoulder lane on the other side. Gaps also occur in areas where Metro Transit believes that there are too many weaves (e.g., a complex freeway interchange) that could create safety hazards if the shoulders were used.
- In freeway segments with auxiliary lanes, buses will tend to stay in the auxiliary lane rather than the shoulder lane because the auxiliary lane usually is free flow or has only minor congestion.
- In addition to all public transit operators, charter buses are now allowed to use the shoulders based on a recent change in state law. There was also an attempt to allow vanpools to use the shoulders, but this proposed law did not pass.
- Deadheading buses are allowed to use the shoulder lanes.
- Present experience is about 20 annual accidents with buses on the shoulders (mainly sideswipes and damaged mirrors).
- The priorities for implementing improvements to the shoulder lanes needed for transit operations are based on number of buses, frequency of congestion, ease and cost of implementation, and the ability to tie the improvements in with another freeway improvement job to minimize costs.
- There is a general sense that the use of shoulder lanes has had a positive impact on ridership. At the same time it is hard to measure the effect, because new service and park-and-ride lots have been implemented over the same period.
- Metro Transit has not evaluated the impact that the use of shoulder lanes has had on operating costs; however, it would like to do so in the future. The key benefit cited is trip reliability; a benefit to both the customer and the operator (in terms of ease of schedule development).
- According to Metro Transit, passenger reaction has been very positive, with 95% of riders surveyed indicating they believed they were saving time (generally higher than actual), and 65% reporting that they had recommended the service to others.

Other interesting facts about Metro Transit's operations follow:

- Although most freeway on-ramps are metered, the meters were removed from the HOV/bus bypass lanes.
- There have been no safety issues between buses/carpools and solo drivers.
- There are concerns about buses not having sufficient acceleration distance from a metered stop to merge safely on to the freeway.

Field Observations

The simplicity of the Twin Cities BBS operation is noteworthy. The signage is minimal and limited to "Shoulder—Authorized Buses Only." These signs were placed approximately one-quarter to one-half mile apart along the freeway shoulders. Where there is a merge with an on- or off-ramp, an additional sign was added to caution the automobile drivers that buses were operating on the shoulder. Bus drivers are trained to yield to automobiles. This was evident at interchanges when automobiles have to merge through the shoulder to access the general traffic lanes.

To better understand the BBS operations, a ride along Route 180 to the Mall of America, an express route operating solely to connect downtown with the Mall and that operates using an articulated bus on the freeway shoulder, is advantageous. The bus traveled during rush hour and the freeway congestion was heavy. Although the actual speed was only 5 to 15 mph faster than the adjacent automobile traffic depending on the traffic conditions at a particular location on the route, the impression passengers get is of a much faster speed because they see themselves passing so many cars. Ridership on Route 180 was substantial, even on the return trip after 8:00 p.m. (more than 30 passengers boarded at the mall).

There was an in-line bus station located just off the side of I-35 at a major arterial crossover. Built in the 1960s, the design lacks customer amenities. Nevertheless, it works and many passengers exit or enter at this station, transferring from other routes along the arterial. There are plans to build a median busway, and the station will be relocated to the median.

It was possible to view the freeway shoulder operation from overpasses at various points along the freeway. One can see how bus drivers reacted to freeway obstructions (there was some construction work underway in the shoulder lane, compelling bus drivers to merge into the mixed-flow lanes) and motorists who were inadvertently blocking the shoulder lane. The team also observed how bus drivers merged with traffic at freeway on- and off-ramps. What was most striking was just how smoothly everything went. Their success appeared to boil down to three key factors:

1. Buses only operate in the shoulders when traffic speeds are low, because the ability to react to changing conditions is much easier at low speeds.
2. Bus drivers are given the discretion of how they respond to various traffic conditions. Rather than over-regulating shoulder lane operations, Metro Transit relies on the professional judgment of its bus drivers.
3. Bus drivers yield to the automobile driver in all cases, thereby minimizing potential conflicts (most notably at on- and off-ramps).

Meetings with Minnesota Transit Team

A one-day meeting of the Minnesota Transit Team was held. This team consists of representatives from MnDOT, Minnesota Transit Agency, private bus operators, Minnesota State Patrol, and representatives of the Regional Transportation Management Center (RTMC). Presentations were provided by each member of the team.

State Highway Patrol

The State Patrol has had very few problems with the bus operations. Last year, operating guidelines for freeway shoulder lane use were added to state law. Therefore, the State Patrol is now able to write speeding tickets to bus drivers that exceed 35 mph while operating in the shoulder. Before being added to state law, the State Patrol had an operating agreement with the Minnesota Transit Agency and MnDOT that outlined the various rules for bus operation.

The State Patrol works very closely with the RTMC and has a zero tolerance towing rule for anything that is in the shoulder while the buses are operating. They have contracted with a towing agency and generally have a vehicle blocking the shoulder towed within 30 min of its first report. MnDOT pays for this service. As part of the RTMC, it has a Highway Helper program that includes Freeway Instant Response, which operates 7 days per week.

The State Patrol also noted that buses have encountered no problems with stalled vehicles and highway patrol cars.

Transit Operators

Metro Transit indicated that driver training primarily takes the form of classroom training on the state law, operating rules, and how to respond to issues. The drivers are not given any extensive in-bus training on driving on the shoulders. However, drivers are given annual safety updates and briefings on shoulder lane use. Metro Transit's operating rules for BBS use are provided in Appendix C.

All operators are allowed discretion in how they operate on the shoulders. If they are not comfortable operating in the shoulders they do not have to. Many of the newer operators are tentative on the shoulders and often will operate at lower speeds or more often in segments where the shoulders are wider. The operators indicated that there is tremendous customer pressure to operate on the shoulders and that passengers will often voice displeasure to drivers that choose not to. The operator is also responsible for gauging the speed of the vehicles in the lane adjacent to the shoulder. The operating rules note that a bus can only travel 15 mph above the speed of the traffic in adjacent lanes. The bus also can never travel faster than 35 mph. If the speed of the vehicles in the adjacent lanes is greater than 35 mph, the bus must merge into the main traffic lanes and not operate on the shoulder.

The operating speed was defined by the transit operators through a survey of their level of comfort operating at various speeds on the shoulder. Most of the operators in that survey indicated that they did not feel comfortable operating above 35 mph at any time in the shoulders. Because of the cold snowy weather in Minnesota, operators are given discretion whether or not to operate in the shoulders when visibility is low, with many choosing not to during heavy snowfall.

Drivers are able to use the shoulder at any time during the day when congestion exists. They are also able to use shoulders for deadheading, which is a major benefit for the operator. All of the express buses operating in the corridor use the freeway shoulder. Suburban operators and private operators are also allowed to access the shoulders. School buses do not have this privilege.

Minnesota DOT

MnDOT is extremely proactive on transit use of shoulders and allocates money toward the ongoing maintenance and expansion of the freeway shoulder lane program. The operation of buses on the shoulder had been incorporated into most of the freeway programs—for example, freeway shoulders are snowplowed before arterials and capital programs provide for gutter replacements and asphalt enhancements.

MnDOT has an overall program that annually reviews where freeway shoulder lanes for transit can be added and where enhancements can be made. The agency was initially concerned about the ability of storm drains on shoulders to withstand the constant travel of buses over them. Given budgetary constraints, MnDOT did not initially concern itself with shoulder lane drainage structures. Over the years however MnDOT implemented a program of reconstructing the drains. Drainage structure improvements include enhancing the concrete structure on the head-end and far-end of the drain structure and raising the structure to surface level when necessary. The drainage structure improvement program is ongoing, with the remaining structures to be improved as funds become available. Also, MnDOT ensures that new shoulders are constructed 12 ft wide, with a 7 in. base, rather than the former specification of a 2 in. base.

MnDOT oversees the signage program for this transit operation. In addition, the agency has been proactive in other avenues that support freeway shoulder lane use. Many of the interchanges include bypass lanes for the buses to access the freeway and it pays for and maintains stations that abut the freeway. Also, MnDOT funds the acquisition of property and the capital cost to build major park-and-ride lots that support the transit operation. One such lot had 1,800 spaces in a four-story structure. The lot was accessible from both sides of the freeway by means of by-pass lanes.

MnDOT indicated that one of the reasons that the project is so successful is the ability to tie shoulder projects to other freeway projects. Because of the extreme winter weather in Minnesota, the maintenance budget for the freeway is substantial.

Customer Perception

Time savings with the freeway shoulder lane use are reportedly in the range of 5 to 15 min for the average trip depending on the level of congestion. An average of 7 min is saved on most trips during peak travel periods. However, the customer perception of the time savings is much higher. Customers view the use of the shoulders not only as time savings, but also as a way to minimize their stress resulting from sitting in traffic congestion. Also, the customer's perception of schedule adherence and trip reliability is much higher given the use of the freeway shoulders.

Next Generation of Shoulder Lanes

MnDOT is currently working on developing a set of guidelines that would outline when shoulder lanes are warranted. Items that could be included in these guidelines are:

- Required metered ramps for shoulder lane use,
- A certain level of congestion during peaks (this is being refined),
- All new freeways to include 12-ft shoulders for transit use (planned or future),
- Catch basins built to support transit use,
- Pavement depth of 7 in. or more to support transit use,
- Number of buses that would use the shoulders,
- Length of delay (related to congestion), and
- Ease of implementation.

Lessons Learned

Lessons learned from this experience indicates that there is potential for the Minneapolis freeway shoulder lane concept to work in other areas for the following reasons:

- Use of the shoulder lanes is limited to transit vehicles driven by professional operators.

- Use of the shoulder lanes is at the transit operator's discretion; there is no requirement that the operator must use the shoulders if it is believed that conditions are unsafe (e.g., inclement weather).
- Use of the shoulder lanes is limited to times when the general lanes are congested; the low speeds in the general traffic lanes, coupled with speed limitations on transit vehicles, allows transit vehicles to adequately respond to potential transit vehicle and automobile conflicts.
- Positive responses from both transit passengers (in terms of time savings and trip reliability) and automobile drivers (in terms of accepting buses in the shoulder lanes).
- Most of the express buses operate on 10-min headways. Because some freeway segments have five or more bus routes in operation, there could be four to five buses operating in caravan fashion along the freeway.
- Cooperation between the transit agency and the DOT was very important. They work to support one another with the overall goal of making the project work. The Team Transit group appeared to work very well together and provided a "can do" attitude about making the system work.
- From the standpoint of traffic safety, benefits to transit operations, and public relations, the use of freeway shoulder lanes has been a success.

Bus Driver Survey

Bus drivers on routes using I-35W and TH-5 were surveyed to determine their reaction and the degree to which they use the bus-only shoulders.

- Most of the drivers used the bus-only shoulders at rush hour during congested situations, although even in good weather most drivers still reported using the bus-only shoulders on a regular basis during the evening peak traffic period.
- A majority of the drivers perceived significant travel time savings when using the bus-only shoulders. On a typical day, they perceived a 5 to 20 min time savings. On a day when traffic is at its worst, they perceived a 10 to 60 min time savings when using the bus-only shoulder lanes.
- Most drivers reported that the bus-only lanes were not wide enough. Most of these drivers were using I-35W, which initially only had a 9.5-ft-wide shoulder.
- A majority of the bus drivers have experienced conflicts with automobile drivers (driving on the edge of shoulder to prevent buses from passing).

Bus Passenger Survey

- Passengers provided the following estimates of travel time savings on atypical days—1 to 3 min (11%), 4 to 6 min (22%), 7 to 9 min (12%), 10 to 30 min (13%), and no answer (42%). Travel time benefits were greater on bad weather days.
- Of those passengers responding, 38% mentioned greater adherence to schedules.

BBS Signage

Signage is very simple as shown in Figures 17–20.

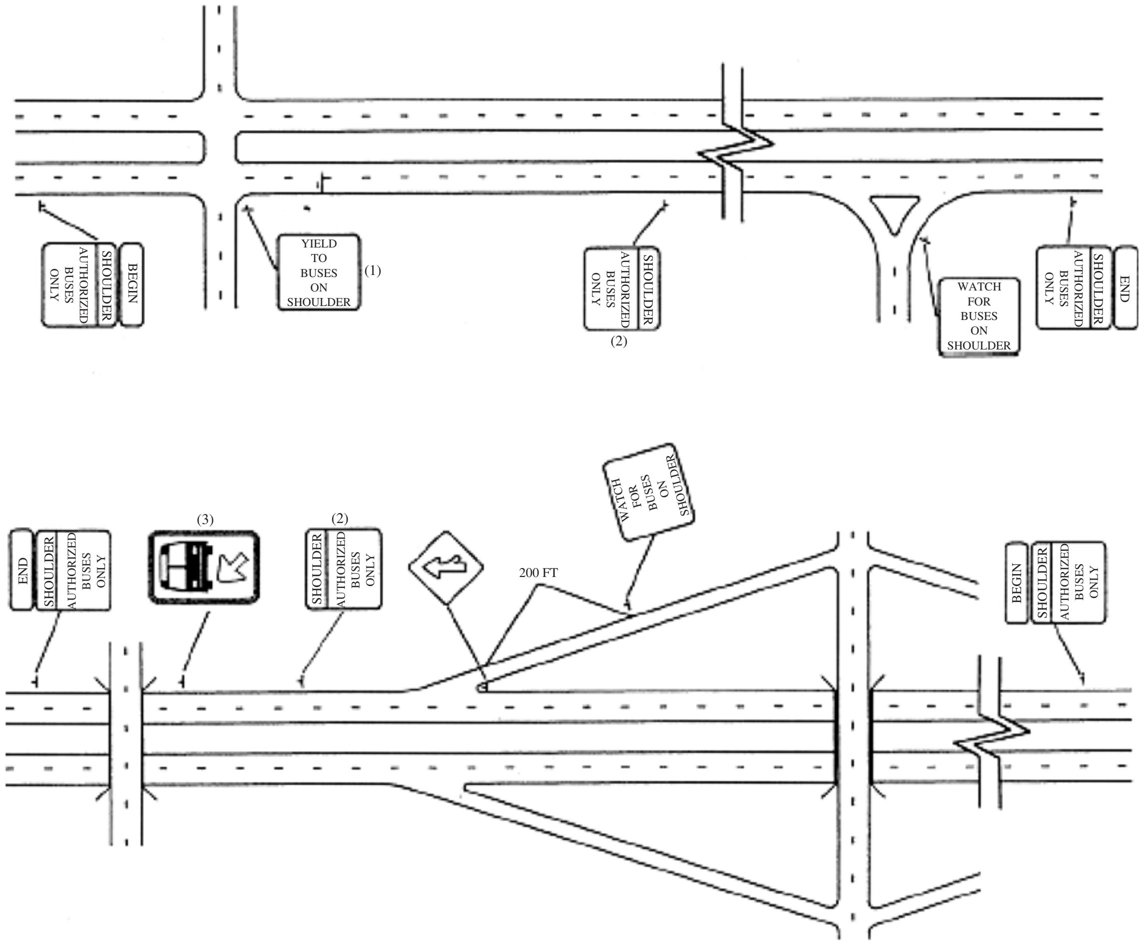
Miscellaneous

- Charter buses are allowed to use the BBS lanes if authorized (permit), although use of the BBS facilities is not encouraged owing to enforcement issues.
- Paratransit vehicles are allowed to use the BBS lanes.
- The biggest benefits of BBS are achieved when the weather is bad and traffic is very congested.
- Passengers often ask the bus drivers to use the BBS lanes, which is an indication of how much they value the travel time advantage.

Shoulder Reconstruction and Construction Costs

When a highway shoulder is being considered for bus-only shoulder use, existing shoulder conditions need to be evaluated to determine what work is required to accommodate the additional dynamic load caused by the buses. The cost of the required improvements depends on specific conditions. Costs also vary depending on whether the shoulder conversion for bus use is an independent project or is included as part of a larger construction project. A 1998 study for MnDOT identified five general conditions when determining whether to upgrade.

- Condition one—Shoulder width and bituminous depth are adequate. Catch basins do not need adjustment. Only signing and striping improvements are required. The average cost for a freeway section is $1,500 per mile. The average cost for an expressway section is $2,500 per mile in 1998 dollars.
- Condition two—Shoulder width and bituminous depth are adequate; however, minor shoulder repairs and catch basin adjustments are needed, and signing and striping improvements are also required. The estimated cost for this work is $5,000 per mile, plus signing and striping costs (1998 dollars).
- Condition three—Shoulder width is adequate, but bituminous depth is insufficient. Shoulder and roadway can be overlaid at the same time. Signing and striping improvements are also required. The estimated cost for this work is $12,000 per mile, assuming a 2 in. bituminous overlay, plus signing and striping costs.
- Condition four—Shoulder width is adequate, but bituminous depth is insufficient. Roadway is not being overlaid; therefore, the bituminous shoulder must be



NOTES: (1) Required only at signalized intersections where right turn on red is permitted.

(2) Install near midpoint when zone exceeds 3 mi and continues at approximately 1.5 mi spacing.

(3) Install as needed to warn bus drivers where shoulder is less than 10 ft.

FIGURE 17 Typical shoulder signage for bus use.

removed, granular base adjusted, and increased bituminous depth replaced. Signing and striping improvements are also required. The estimated cost for this work is between $32,500 and $41,500, plus signing and striping costs.

- Condition five—Shoulder width is inadequate; widening and depth replacement are required. Signing and striping improvements are also required. The estimated cost for this work is between $42,000 and $66,000 per mile, plus signing and striping costs.

CASE STUDY 2—FALLS CHURCH, VIRGINIA

The emergency shoulder was widened along a 1.3-mi portion of eastbound VA-267 (known as the Dulles Connector along this stretch), between the Magarity Road overpass (just downstream of the Route 123 eastbound on-ramp) and the off-ramp to the West Falls Church Metrorail station. Figure 21 shows the regional context for the BBS and Figure 22 depicts how the BBS feeds the West Falls Church Metrorail Station. Transit buses (not other buses or vans) can use the emergency shoulder only when necessary to bypass mainline congestion Monday through Friday between 4 p.m. and 8 p.m. (originally from 5 p.m. to 7 p.m., but extended after an initial test period proved operations were running well and there was a definite advantage to extending). Because the speed limit on the shoulder is 25 mph, bus drivers have no incentive to using the shoulder unless mainline speeds drop below that level. The main reason for the queues along the eastbound Dulles Connector during the BBS hours is the difficulty motorists have merging onto congested eastbound I-66.

The project was designed in coordination with the Virginia State Police (VSP) and Metropolitan Washington Airports Authority [MWAA, which owns the right-of-way; Virginia DOT (VDOT) operates the facility under agreement

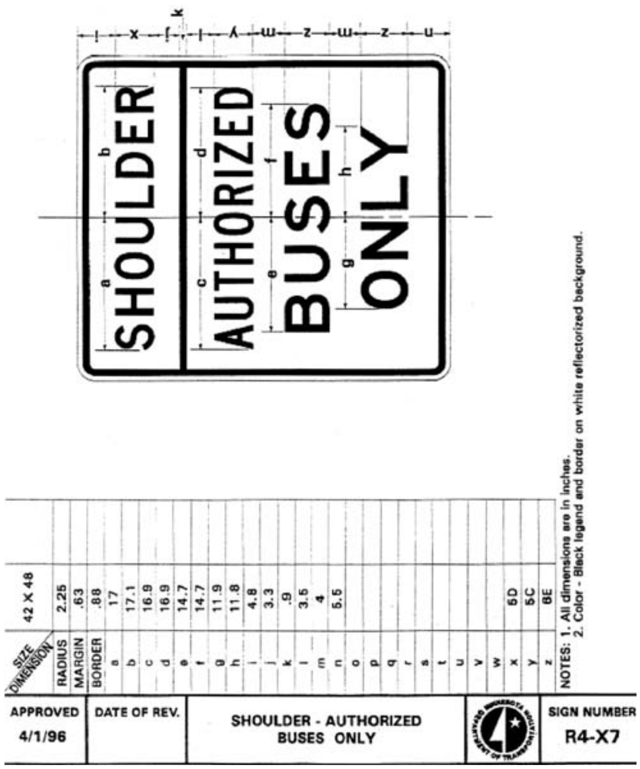


FIGURE 18 BBS signage: Shoulder—Authorized Buses Only.

with MWAA]. VDOT obtained approval from FHWA because design exceptions were necessary for the narrow inside shoulder above a bridge. Narrowing the inside shoulder was considered preferable to narrowing mainline lanes. VSP stressed the need to keep the shoulder looking like an emergency shoulder; therefore, a double solid white line was used to separate the mainline traffic lanes from the BBS shoulder (the initial pavement markings using dashed lines at the beginning and end of the segment were corrected, because they seemed to "invite" unfamiliar commuters to use the shoulder). VSP keeps copies of the executed letters of understanding from the "authorized" transit users so that they can refer to them if necessary for enforcement.

An additional sign is located toward the end of the shoulder that advises bus drivers to yield to off-ramp traffic.

Virginia also operates a general traffic shoulder lane project on I-66 near the Dulles Access Road BBS project. Time-restricted use of this general traffic lane is defined more boldly than the signage used for the BBS facilities.

During the shoulder's initial trial period and before extending the shoulder hours of operation from 5 p.m. to 7 p.m. to 4 p.m. to 8 p.m., Fairfax County (whose buses are the main beneficiaries of the shoulder) conducted, a study to determine number, classification, and speed of vehicles using the shoulder. Some corrective enforcement measures were needed (a few passenger cars were using the shoulder and a few buses were traveling at more than 25 mph). The follow-

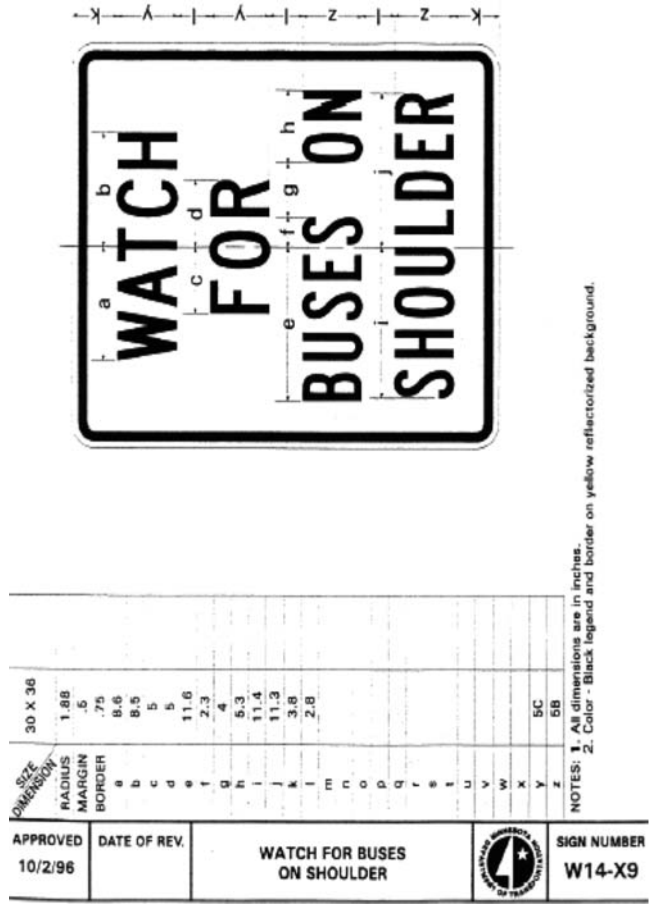


FIGURE 19 BBS signage: Watch for Buses on Shoulder.

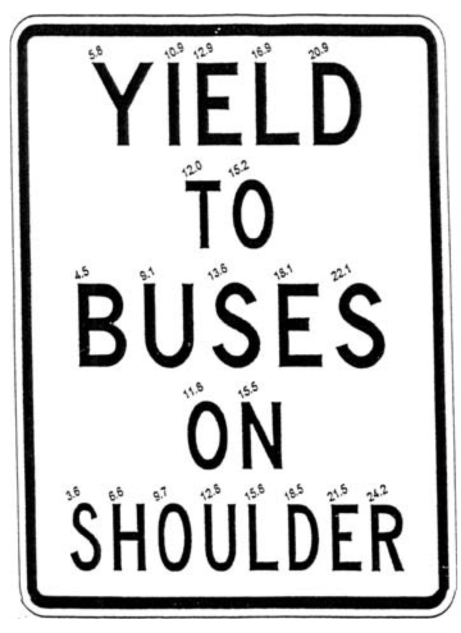


FIGURE 20 BBS signage: Yield to Buses on Shoulder.

ing checklist was developed to facilitate enforcement, which appears to have paid off. There have been no further reports of unauthorized vehicles using the shoulder or buses going faster than 25 mph.

CHECKLIST

PROVISIONS FOR USE OF WIDENED EMERGENCY SHOULDER EASTBOUND DULLES AIRPORT CONNECTOR ROAD

– **Who** can use widened shoulder: Buses going to the West Falls Church Metro Station.
– **Location:** Widened shoulder along eastbound Dulles Airport Connector Road, from east of the Magarity Road overpass to the ramp leading to the West Falls Church Metro Station (a distance of approximately 1.3 miles).
– **Days, Times, Conditions:** Monday through Friday, during the hours posted on the signs installed along the shoulder,* only when mainline speeds are less than 25 miles per hour.
(* Note: As of 10/25/01 posted hours of operation are 4–8 p.m.)
– **Speed Limit** on the shoulder is 25 miles per hour.
– **Primary Use of Shoulder** is for disabled, emergency, and police vehicles. Periodic use of shoulder by buses to bypass congestion is secondary to its primary use.
– **Safety First.** Buses must have their headlights turned on when using the shoulder. Bus drivers must use extra care and keep a sharp lookout for disabled or stopped vehicles on the shoulder, and for situations which may require vehicles responding to an emergency to use the shoulder. Dispatchers will inform bus drivers whenever the dispatchers are notified of such a situation. If the shoulder is occupied by a stopped vehicle, bus drivers shall not use the shoulder west (upstream) of stopped vehicle.
– **Shoulder Conditions.** Buses may not use the shoulder when snow accumulation has narrowed its available width.

Feedback has been positive; "riders are thrilled at bus schedule reliability."

CASE STUDY 3—MIAMI, FLORIDA

The Miami–Dade MPO is developing BBS projects for several major corridors. This BBS planning involved the Florida DOT, Miami–Dade Expressway Authority, Miami–Dade Transit, and the Turnpike Authority. The recommended BBS projects include:

- SR-821/SR-836 Corridor
- I-75/SR-826 Corridor
- SR-826 Corridor
- I-95 Corridor
- SR-874 Corridor.

SR-821/SR-836 Corridor

SR-821 is a portion of the Florida Turnpike, and the BBS segment in southwest Miami is sometimes referred to as the Homestead Extension of the Florida Turnpike. SR-836 is commonly called the Dolphin Expressway. The SR-821/SR-836 BBS project is an 18-mi-long facility with more than a dozen interchanges (with an average of 1.4 mi between interchanges). The BBS project would extend from SW 88th Street (near Bird Road) on the Florida Turnpike to SR-836 and eastward to I-95. This corridor was determined to be the most promising BBS project. Buses operating on this corridor would need to be fitted with transponders to use the express "sun pass" toll lanes. The BBS lanes would be continuous over the length of the corridor in both directions of travel. Initial implementation is anticipated for May or June 2006.

I-75/SR-826 Corridor

This BBS project would run between NW 186th Street (Miami Gardens Drive) and the Miramar Parkway. The distance is approximately 15 mi and the segment has about 10 interchanges (with an average distance between interchanges of 1.5 mi). BBS shoulders would operate in both directions of travel when speeds drop to 35 mph or less. BBS would be easy to implement in this corridor because shoulders are suitably designed. BBS signage would be the primary improvement required.

SR-826 Corridor

The SR-826 (Palmetto Expressway) BBS would extend from SR-94 (Kendall Drive) to NW 67th Street (near I-75), a distance of 16 mi. The Palmetto Expressway BBS segment has about 15 interchanges, which translates to an average of 1.1 mi between interchanges. BBS shoulders would be provided for both directions of travel.

I-95 Corridor

A BBS project between I-195 and I-395 is proposed to fill a gap in the regional transit priority network. The distance of this BBS segment would be approximately 1.6 mi. Shoulders would be provided for authorized buses in both directions of travel.

SR-874 Corridor

The BBS project would extend from SR-990 (Killian Parkway) on SR-874 (Don Shula Expressway) to US-1 South Dixie Highway on SR-878 (Snapper Creek Expressway). The SR-874 BBS distance would be approximately 2.6 mi.

The MPO completed a planning study for these BBS projects in August 2005. The planning study addressed adequacy of the shoulders, level of emergency vehicle response service using the shoulders, and transit services. Key features of the plan are:

- Shoulder features—Minimum 10 ft wide, and 12 ft wide where truck volumes exceed 250 vehicles per hour. Cross slopes of 2% to 6%. Color or texture of pavement to distinguish between traffic lanes.
- Usage rules—When speeds drop below 35 mph. Only authorized buses would be permitted and signage would be similar to that used in Minneapolis. This would include the on-ramp warning signs; "Watch for Buses on Shoulder."

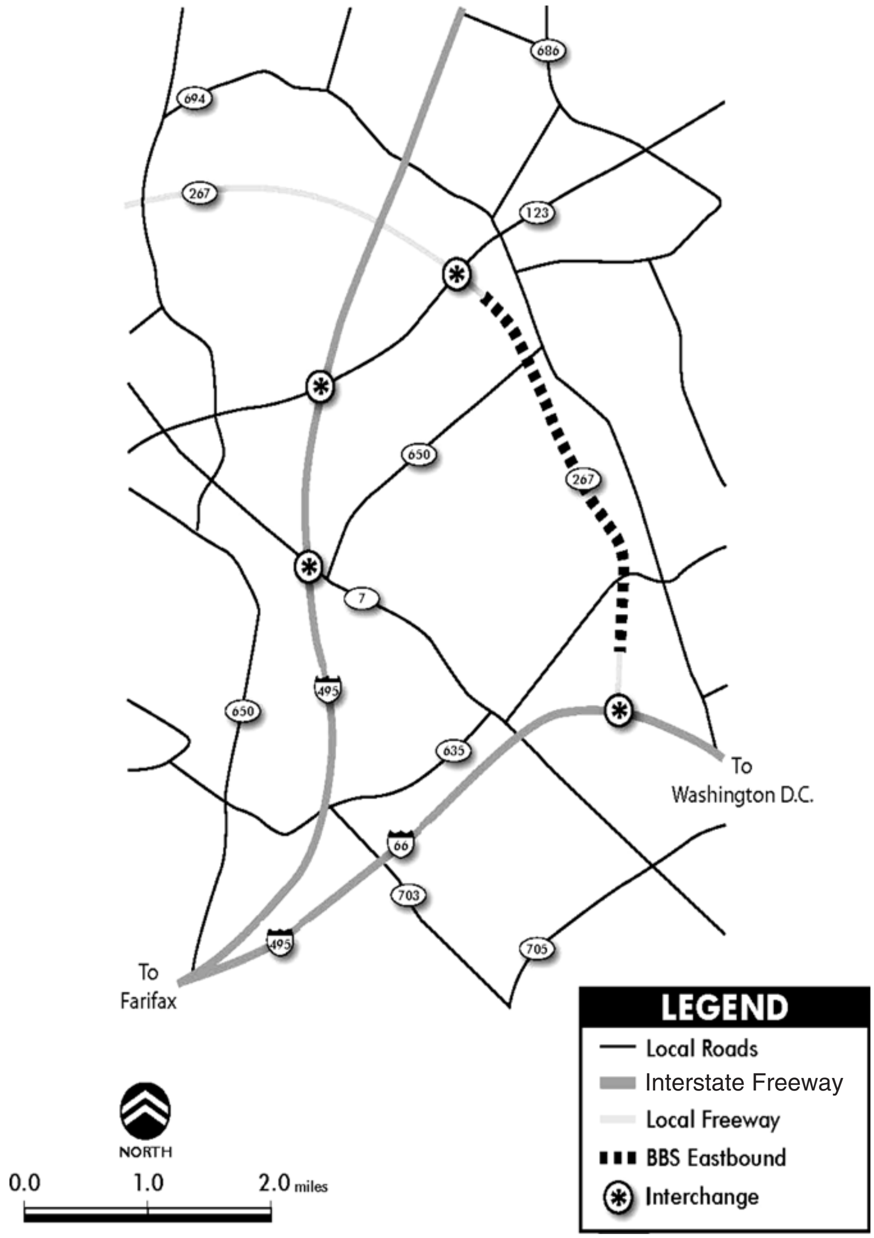


FIGURE 21 Virginia Freeway 267 eastbound BBS.

CASE STUDY 4—SAN DIEGO, CALIFORNIA

Background

A key element of SANDAG's Transit First strategy is the use of transit priority measures along freeways and arterials to bypass congested areas. These measures are expected to increase transit speeds and improve schedule reliability.

The SANDAG BBS demonstration project will evaluate the feasibility of converting freeway shoulder lanes on SR-52 (between Kearny Villa Road and I-805) and I-805 (between SR-52 and Nobel Drive) to transit-only lanes that would be used by existing express Route 960. This project includes a formal agreement between SANDAG and Caltrans to allow for the implementation of a 1-year pilot project. This agreement describes the key elements and strategy for the planning, design, and implementation of this project. After gaining approvals from key agencies the demonstration project opened in December 2005. Figure 23 shows the BBS segments that were implemented.

Use of the BBS lanes is restricted to authorized buses only ("Transit Lane Authorized Buses Only" signs are posted). No special pavement markings are used to define the BBS. Buses are only permitted to use the BBS lanes when speeds on the general traffic lanes drop to 30 mph or less. When using the shoulders, buses are only allowed to travel at 10 mph faster than traffic in the general traffic lanes.

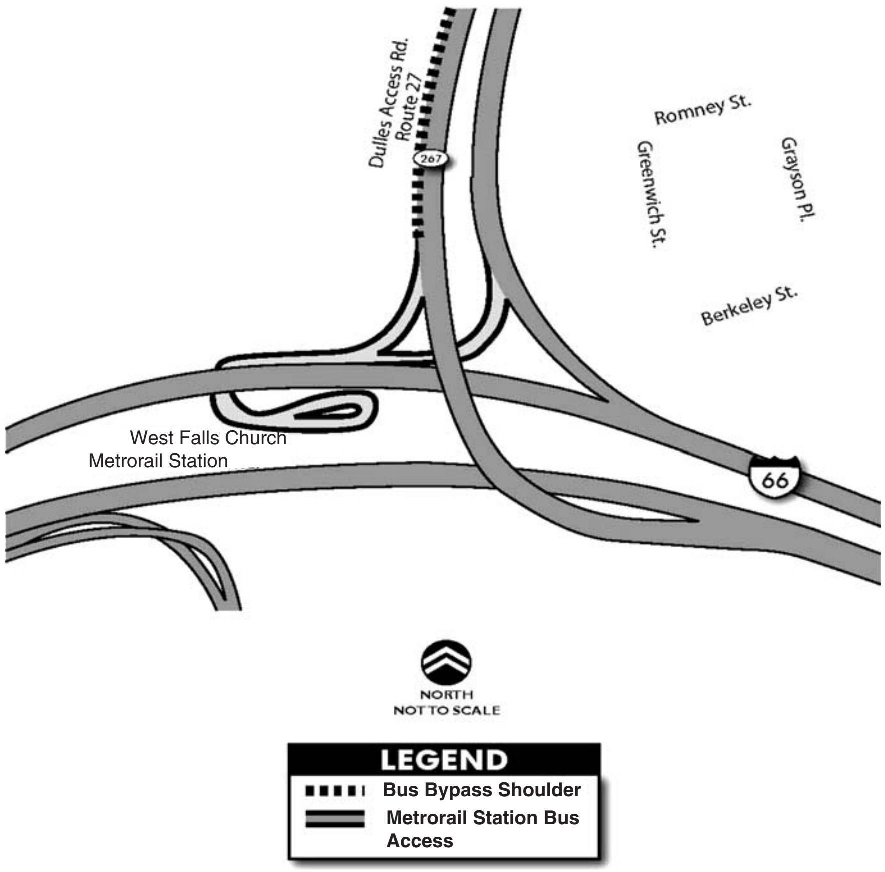


FIGURE 22 West Falls Church Metro Station BBS terminals.

Project Purpose

The purpose of the BBS pilot project is to demonstrate the operational feasibility of buses using freeway shoulders as transit lanes. The project will:

- Address the requirements of existing Caltrans policy on shoulder use.
- Address the requirements of Street and Highway Code Section 149 regarding Preferential Lanes.
- Develop interagency agreements regarding liability, maintenance, and enforcement.
- Ensure coordination with FHWA on the I-805 segment.
- Develop performance measures and monitoring parameters for the project.
- Prepare a final report for approval to implement the project.

The following benefits are anticipated:

- Implement Transit First Vision.
- Demonstrate the usefulness of freeway shoulders as transit lanes during periods of heavy congestion for transit operations.
- Measure bus passenger, bus driver, and automobile driver perceptions.
- Determine the impacts to travel time reliability.
- Monitor the operating benefits and safety of the conversion of the shoulder lanes to transit lanes.
- Assess the applicability of converting freeway shoulders to transit lanes on other freeways sections.

Project Description

The project involves a 1-year pilot implementation of the transit shoulder lanes to evaluate operational and safety implications. The results will be used to assess the potential of expanding the use of transit shoulder lanes in other freeway corridors.

The preparation of the proposed project required that SANDAG assemble a multidisciplinary team from SANDAG, Caltrans, CHP, and transit operator (Metropolitan Transit System), to study and implement the project. Figure 24 illustrates the program's partnership signage.

Performance Measures

SANDAG and Caltrans prepared a monitoring plan to assess the expected versus actual effects of the proposed transit lane. Initially, the transit lane alternative will be evaluated and

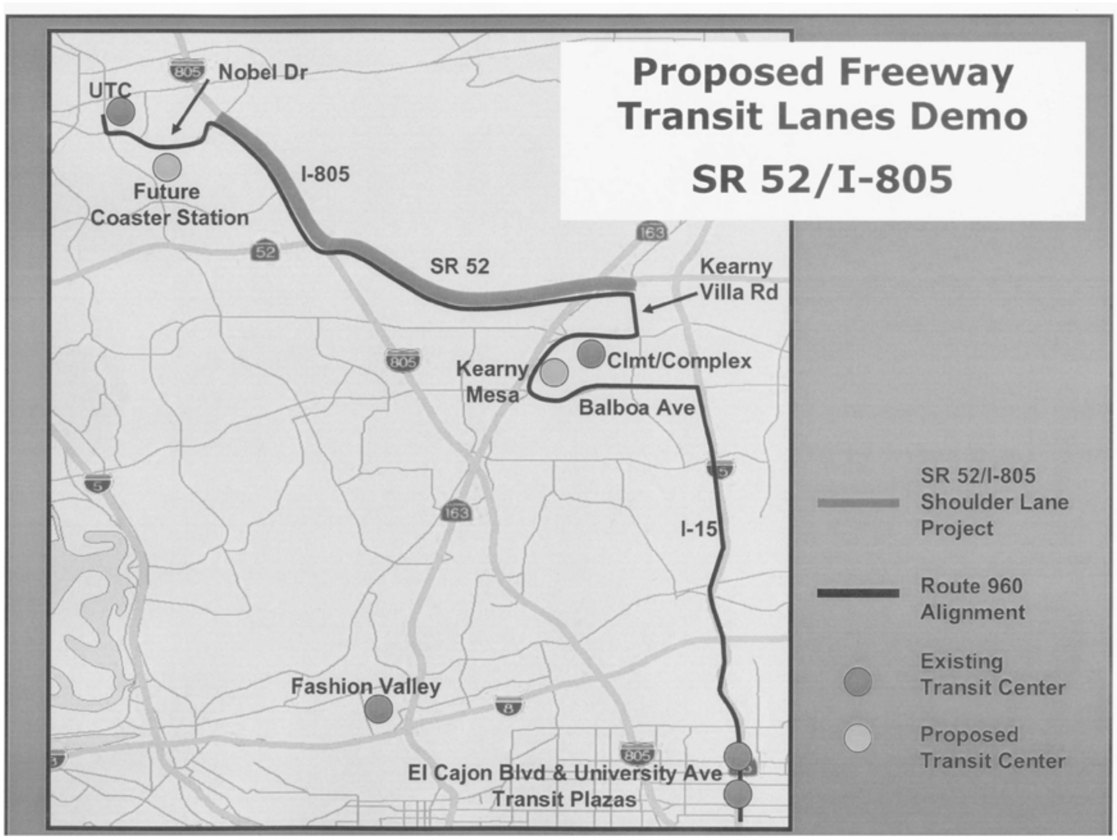


FIGURE 23 SR-52/I-805 proposed transit lane demonstration segments.

compared with the existing condition for the following performance measures:

- Transit travel time reliability;
- Automobile driver, transit driver, and transit passenger perceptions;
- Traffic and transit vehicle operations; and
- Safety.

Once the initial evaluation is complete, SANDAG and Caltrans will prepare a Monitoring Plan that will lay out roles, responsibilities, data needs, and measurement methods for ongoing project monitoring and reevaluation. The plan will be framed around the four major issues noted previously and designed to answer the basic questions noted in the "Project Purpose" described earlier.

FIGURE 24 SANDAG program's partnership signage.

Although transit vehicles have been using freeway shoulder lanes safely and successfully in Minnesota for 12 years, there is no analogous California experience. There has been agreement for some time now between Caltrans District 11 and SANDAG staffs on the potential benefits of freeway shoulder lane use to existing freeway express transit and future Bus Rapid Transit services. Currently, however, the California Streets and Highways Code prohibits use of shoulder lanes as travel lanes. Allowing even a limited number of transit vehicles in the shoulders during the peak period is apparently not allowed either. To address these restrictions, a demonstration project was developed in which the shoulder lanes are converted to transit-only lanes. Pull-out areas outside of the transit-only lanes were created for enforcement activities and disabled vehicles.

The California State Streets and Highways Code allows for creation of transit-only lanes provided engineering studies are conducted on the effect of such lanes on safety, congestion, and highway capacity. The pilot project site is the State Route 52/Interstate 805 (SR-52/I-805) Corridor between Kearny Mesa and University City. These freeway segments represent prime candidates for the demonstration project owing to the presence of several positive characteristics, including sufficient existing shoulder width, no existing or planned construction activities, and heavy peak-period congestion levels. Route 960 operates along the demonstration corridor with about five morning and six evening roundtrips.

The intent of the freeway transit lane demonstration project is to gain local operational experience with the conversion of the existing shoulder lanes to transit lanes during the peak periods. In turn, this operational experience would help define the physical elements required to successfully operate freeway transit-only lanes in other freeway corridors where existing express services and future BRT services will operate. The demonstration project will address five key objectives:

- Safety—Is there any change in accident rates with buses using the transit-only lanes, and do CHP officers and Caltrans maintenance crews experience safety-related problems?
- Bus Travel Time and Reliability—Do buses experience a measurable and repeatable travel time savings and enhanced trip reliability (on-time performance)?
- Bus and Automobile Driver and Bus Passenger Perception—Do bus drivers feel safe using the transit-only lanes and are automobile drivers comfortable with buses merging in and out of the transit-only lanes; also, do transit riders perceive improved travel time and trip reliability and do they feel safe with the bus operating in the transit-only lane?
- Maintenance—Is there any reduction in freeway levels of service from the transit-only lanes, and is there an increased level of maintenance required?
- What kinds of physical improvements to shoulder lanes would be required if this concept were to be implemented permanently?

The year-long demonstration period will test how the transit lanes operate. A monitoring program will assess the expected versus actual effects of the transit-only lane. A final report following the demonstration period will be used to determine whether to make the freeway transit lane permanent and if and how the concept could be applied to other freeway corridors. Assuming the design studies judge the demonstration feasible, the physical improvements necessary would be implemented and operation of the demonstration could begin within 12 to 15 months.

CASE STUDY 5—TORONTO, ONTARIO

The Central Region of the Ministry of Transportation (the "Ministry" or MTO) initiated and evaluated the use of the right shoulder of Highway 403 between Erin Mills Parkway and Mavis Road by authorized transit operators. Designated shoulders for use as a BBS appear similar to and still operate like any other freeway shoulder; however, authorized transit operators are permitted to use the shoulder in designated areas to bypass congestion.

Criteria for Eligibility

Operating protocols that were adopted for implementation of the BBS in the fall of 2003 are reported in this case study.

The use of the BBS is limited to those bus operators who are authorized by the MTO. Currently, only GO Transit and Mississauga Transit (each referred to herein as a "Bus Operator") are authorized to use the BBS on Highway 403. Additional bus operators may be permitted in the future. As additional bus operators are authorized to use the designated shoulders, the Ministry will notify local Ontario Provincial Police (OPP) detachments and the transit operators that are already authorized to use the BBS.

Each Bus Operator must ensure that all bus drivers who will use the BBS have received a copy of the Operating Protocol, have been provided with training concerning the use of the BBS, and have agreed to the conditions of operating a bus in the BBS as outlined in this Protocol in the following bulleted list. GO Transit provides the required training services to all Bus Operators using the BBS on a cost-recovery basis. The Bus Operators are responsible for monitoring the operations of their drivers and vehicles to ensure compliance to the protocol.

- Bus operators must provide regular, scheduled service available to the public.
- Only 40- to 60-ft buses and articulated transit buses will be permitted to use the BBS.
- Buses must have radio or telephone contact with the Bus Operator's central dispatcher to report blocked shoulders or other emergency situations involving the shoulder.
- Bus Operators using the BBS must have a Commercial Vehicle Operator's Registration certificate, and must have a Carrier Safety Rating of either excellent or satisfactory. The Ministry's Central Region designated contact must be provided with proof of this rate.
- Bus Operator's supervisory and driver staff must complete Manager and Driver Training as provided by GO Transit before commencing operations. The BBS Training Presentation for bus drivers is described in Appendix C. The curriculum includes:
  - Purpose of BBS;
  - Review of BBS layout, signs, and markings;
  - Operating speed restrictions;
  - Safe merging;
  - BBS access and egress; and
  - Emergency procedures.

After completion of training, each supervisor and bus driver must sign an acknowledgment form indicating that they have been trained and will abide by the rules of this Operating Protocol. The Bus Operator must retain a copy of each signed form for the MTO's review.

Before commencing operations, the Bus Operator must sign the BBS Operating Protocol. Each signatory must have the authority to bind his or her corporation.

Buses using the BBS must have radio or telephone contact with their central dispatcher to report blocked shoulders or other emergency situations. Any information reported to their central dispatcher must be passed along by the dispatcher to the respective emergency service (e.g., police, fire, or ambulance) and to MTO COMPASS Operations, Downsview.

Operating Partners

The Operating Partners to this Operating Protocol are the MTO, Mississauga Transit, GO Transit, and the Ontario Provincial Police.

Design

The Highway 403 BBS extends on the right shoulder between Erin Mills Parkway and Mavis Road, in both directions (Figure 25). A bus pass-through connection is provided at the Erin Mills Parkway northbound to the Highway 403 eastbound ramp. The BBS is 3.75 m (12.3 ft) wide, with rumble strips dividing the shoulder from the GPLs.

Signing and Pavement Markings

The BBS is clearly marked with signs approximately every 200 to 300 m along its entire length to inform motorists that the right shoulder has been designated for use by authorized bus operators (see Figure 26). The solid white edge line between the GPLs and the shoulder is 20 cm wide rather than the normal 10 cm wide.

Bus drivers must exercise their best judgment in considering the safety of other motorists, as well as that of the bus passengers. Bus drivers will only use the BBS when traffic in the GPL is moving at speeds less than or equal to 60 km/h (35 mph). While using the BBS, bus speed shall not exceed 60 km/h. When the general purpose traffic on Highway 403 is in a stop-and-go mode, buses are to travel no more than 20 km/h faster than the general purpose flow of traffic. Bus drivers must adhere to these speed limits; failure to do so can result in the Ministry canceling the Operating Protocol for Bus Operators with repeat violations.

Collisions

In the event of a collision in or adjacent to the BBS, the Bus Operator's Central Dispatch must notify the appropriate emergency service either by calling 911 or the OPP. The Bus Operator's Central Dispatch must then contact MTO COMPASS Operations, Downsview, as soon as possible.

Obstruction of the Bus Bypass Shoulder

During winter months the BBS may be temporarily blocked by snow. Bus drivers are responsible for exercising their best judgment in determining if they can safely use the BBS under these conditions.

If the shoulder is obstructed in any way; for example, by a collision, vehicle breakdown, or debris, the bus driver must reenter the GPL to avoid the obstruction. Buses must yield to other vehicles when reentering the GPL.

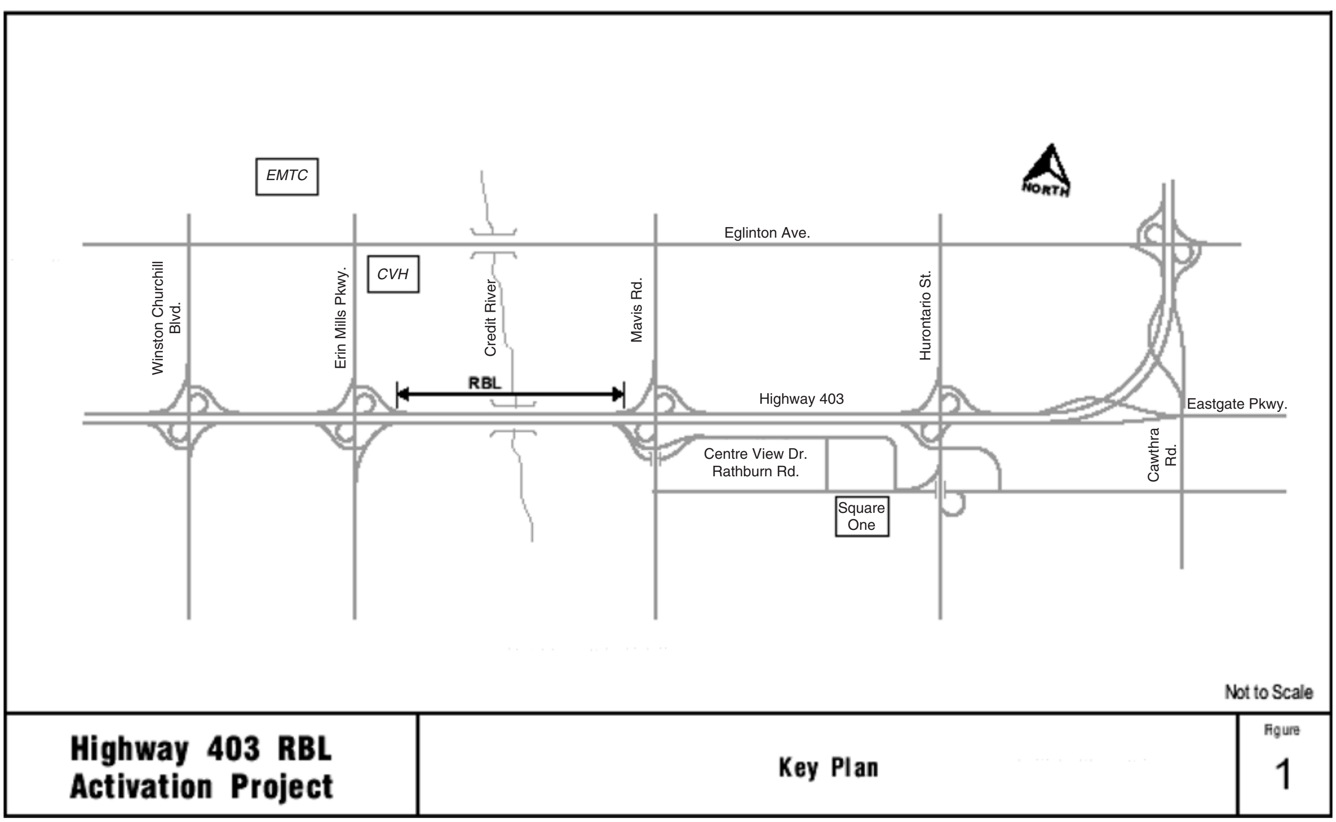


FIGURE 25 BBS on Highway 403.

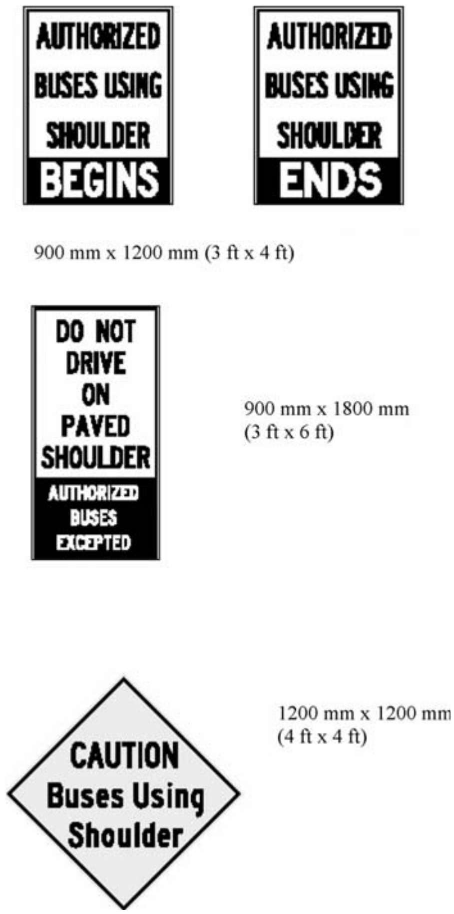


FIGURE 26 Signage marking along the Highway 403 BBS

Bus drivers are to notify their central dispatch of an obstruction on the shoulder and central dispatch will in turn notify all buses that are using the BBS of the obstruction, plus inform MTO COMPASS Operations. The BBS is not to be used until the obstruction is removed from the shoulder.

If necessary, buses in the BBS should safely exit the shoulder to allow emergency vehicles to pass. If the shoulder is not blocked by the emergency, use of the BBS can resume once the emergency vehicle has passed.

On occasion, the MTO or OPP may elect to use the BBS to detour general purpose traffic because of maintenance, construction, or collisions. Except for emergency situations, the MTO will provide the Bus Operators with as much notice as possible and at least 24 h notice.

Times of Use and Hours of Operation

The BBS is to be used for congestion bypass purposes only. Typically, the BBS will be used on weekdays from 6:00 a.m. to 10:00 a.m. in the eastbound direction and 4:00 p.m. to 7:00 p.m. in the westbound direction. The BBS is generally not to be used on weekends unless an incident or event has resulted in the GPL operating at a speed less than 60 km/h.

The BBS may also be used for the duration of any prolonged congestion event outside of peak period hours, provided the speed of the general traffic is 60 km/h or less.

Enforcement

The police provided a higher level of enforcement services during the initial weeks of the BBS operation to ensure its safe and effective operation. The police provided a minimum of six peak hour enforcement periods per week for the first 2 weeks of the initial opening of the BBS, and a minimum of eight peak hour enforcement periods for the next 4 weeks of operation.

Following the initial 6 weeks of higher enforcement levels, enforcement was reduced and provided when necessary and resources are available. MTO provides enforcement sites within the facility.

Facility Maintenance

The MTO is attempting to provide the same level of maintenance for the BBS as provided for the GPL on Highway 403 through this area. However, owing to the nature of the shoulder configuration, it is not always possible to fully clear the shoulder as quickly as the GPL. On these occasions, bus operators must use the GPL until the shoulders are fully cleared.

The design of the enforcement sites makes removal of snow difficult. For this reason, winter maintenance of the enforcement sites is not feasible.

Access and Egress to the Bus Bypass Shoulder

General

As mentioned previously, buses only use the BBS when traffic in the GPLs is moving at speeds equal to or less than 60 km/h. When using the BBS, buses shall not exceed 60 km/h. When the GPL traffic on Highway 403 is in a stop-and-go mode, buses are to travel no more than 20 km/h faster than the GPL flow of traffic.

Once a bus has entered the BBS it shall not reenter the GPL if the operating speed of that lane improves, but should continue to the end of the BBS to minimize potential conflicts with GPL traffic.

Eastbound

When the operating speed of Highway 403 is less than or equal to 60 km/h before the ramp exit at Erin Mills Parkway, buses should exit at the Parkway and enter the BBS from the dedicated bus ramp connection at the Parkway interchange. When exiting eastbound Highway 403 at Erin Mills Parkway, buses must access the dedicated bus ramp connection from the center lane of the ramp.

When Highway 403 traffic is operating at speeds of greater than 60 km/h at Erin Mills Parkway, but the operating speeds decrease beyond the Parkway interchange, buses are permitted to enter the BBS at any location beyond the end of the speed change lane taper for the on-ramp from northbound Erin Mills Parkway. As stated previously, once in the BBS, buses are to remain there until they either exit at Mavis Road or merge with the GPL traffic at the end of the BBS.

When the BBS is in use, buses that are southbound on Erin Mills Parkway will access the dedicated bus ramp connection from the southbound bus-only left-turn lane. The southbound approach has a traffic signal that will give left-turning buses added priority (Figure 27).

Buses that are not exiting Highway 403 at the Mavis Road interchange will merge safely with GPL traffic before the

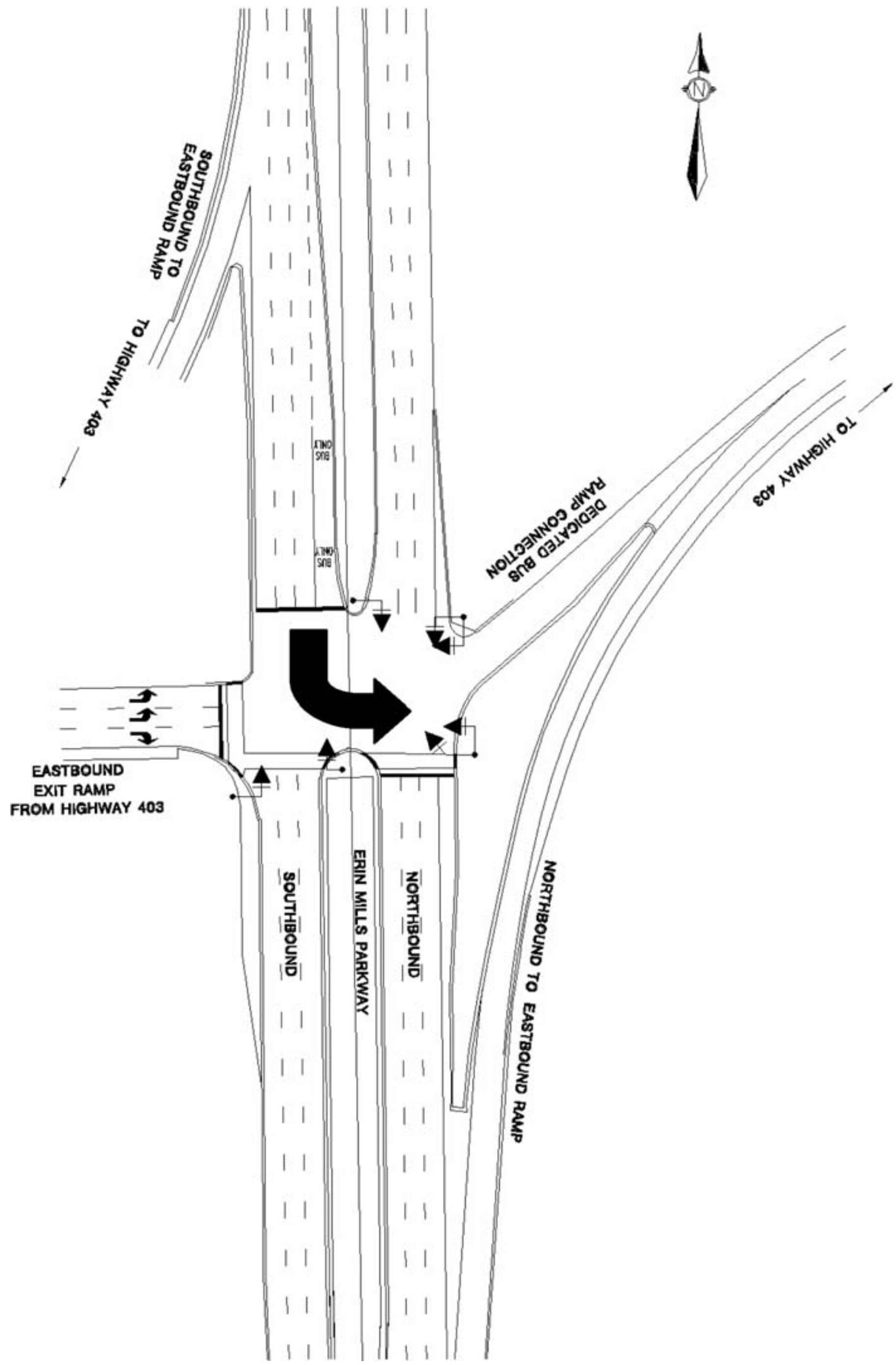


FIGURE 27 Bus movements: Erin Mills Parkway southbound to 403 BBS eastbound. Buses southbound on Erin Mills Parkway will access the dedicated bus ramp connection from the southbound bus-only left-turn lane. The large solid arrow on the diagram illustrates this movement.

start of the speed change lane taper for the Mavis Road exit. Those buses that continue in the BBS adjacent to the ramp will continue on the shoulder and enter the right-turn lane with the ramp traffic when it is safe to do so.

Westbound

Buses entering Highway 403 by means of Mavis Road northbound to the Highway 403 westbound ramp will merge with the GPL and enter the BBS beyond the end of the speed change taper of the Highway 403 on-ramp from Mavis Road southbound when it is safe to do so. At no time will a bus enter the southbound Mavis Road to Highway 403 on-ramp speed change lane to access the BBS.

Buses already traveling on Highway 403 before Mavis Road must enter the BBS beyond the end of the Mavis Road southbound on-ramp speed change lane taper when it is safe to do so.

Buses that are not exiting Highway 403 at the Erin Mills Parkway interchange will merge safely with the GPL traffic before the start of the off-ramp speed change lane taper. Those buses that continue in the BBS adjacent to the ramp will merge with the ramp traffic when it is safe to do so. Those buses that continue in the BBS adjacent to the ramp will continue on the shoulder and enter the right-turn lane with the ramp traffic when it is safe to do so.

Reporting and Liaison

In addition to contacting the appropriate emergency services at the time of a collision, the Bus Operators must report to MTO the details of any collisions involving their vehicles using the BBS immediately after their occurrence. Details will include: date, time, location, traffic conditions, weather and pavement conditions, vehicles involved, sequence of events, damages and injuries, possibility of charges, and recommended measures to avoid recurrence. The report is to be e-mailed or faxed to the designated MTO contact.

Forecast of Use

On a bi-annual basis (September 1 and April 1) each Bus Operator must provide to MTO an estimate of bus routing, schedule, and bus volumes for the upcoming 6-month period. This will include an estimate of total trips, on a peak period and on a per day basis, that will use each direction of the BBS. This information is to be sent to the designated MTO contact. The Ministry will then provide written approval. Each Bus Operator can add bus services to the BBS up to 25% over the submitted estimate before having to obtain further written approval from the MTO. The Ministry determines if additional buses or changes to the operating times will be permitted beyond this agreed estimate.

Bi-Annual Meetings

The Operating Partners meet on at least a bi-annual basis to review BBS operations and agree on changes and improvements.

Evaluation of Bus Bypass Shoulder Use

The Ministry monitors the operation of the BBS and assesses the impacts of the BBS on the GPL. The Ministry reports to the Bus Operators and the police any observed problems or violations of this Operating Protocol, including excessive speed on the BBS or unsafe merging activity. The Ministry notifies the Bus Operator when a problem has been observed and can issue a warning that the Ministry may cancel this Operating Protocol if further violations are observed.

Media Releases

All Operating Partners should make every effort to share, in confidence, any media releases pertaining to the BBS with all Operating Partners, at least 24 h in advance of its release.

Termination of Operations

With the exception of an emergency, any of the Operating Partners may terminate their participation in their BBS operation with 30 days notice, in writing, to the designated contacts of the other Operating Partners. The MTO reserves the right to terminate or suspend operations, with minimal or no notice if, in the opinion of the Ministry's Regional Director, there are significant traffic safety or operational concerns.

Liability

The Ministry is not liable for any consequences that may result from termination of the operation of the BBS. By using the shoulders and agreeing to the Operating Protocol, the Bus Operators acknowledge and accept the more limited operating conditions of the BBS compared with the highway GPL.

CASE STUDY 6—DUBLIN, IRELAND

BBS operations in Dublin began in 1998. The operations amount to 50 to 70 mi, most of which are classified as urban approach roads with at-grade intersections rather than freeway facilities. Hours of operation vary, with some shoulders open 24 h and others open from:

- 7 a.m. to 7 p.m.,
- 7 a.m. to 10 a.m.,
- 12:30 p.m. to 7:30 p.m., or
- 4 p.m. to 7 p.m.

Some BBS segments operate Monday through Saturday and some are 7-day-a-week operations. Buses and taxis are permitted to use the shoulder lanes (termed "hard shoulders" in Ireland). Public transit headways range from 1 to 15 min during the peak commute hours. Buses are allowed to operate up to the posted speed limits while using the shoulders (this varies from 31 to 63 mph).

Figure 28 shows the BBS signage standards that are employed in Ireland. Signage costs tend to be minimal (less than 5% of BBS cost). A 10-in.-wide continuous solid white line is used to distinguish the BBS shoulder from general traffic lanes. BBS shoulders are constructed to the full pavement strength of general traffic lanes and are at least 10 ft wide.

Northern Ireland monitors the use of two BBS facilities with cameras and manages traffic with rotating prism signs along the corridor. If a bus breaks down on the shoulder, the camera monitor will change signs to advise other buses of the blockage. One of the BBS camera applications has been in operation for several years and "has been very successful at getting buses past congestion and has not contributed to any accidents."

According to the Dublin Transportation Office the BBS operation "has allowed significant benefits to public and private bus transport on approaches and within urban areas. As congestion creeps further from the city into the outer traffic arteries the requirement to implement additional and/or extensions of the bus priority lanes is becoming more important." Figure 29 reports travel time savings afforded by BBS and bus priority treatments for major travel corridors. Figure 30 shows the number of buses and bus passengers for key corridors.

FIGURE 28 BBS signage standards as used in Ireland.

QUALITY BUS CORRIDOR MONITORING NOVEMBER 2003
SUMMARY OF AM PEAK COMPARATIVE BUS AND CAR JOURNEY TIMES

Corridor	Section Measured	Bus Average Journey Time	Car Average Journey Time	% Difference
Finglas	Finglas to Dorset St Lower	11:46	20:20	72.8%
Stillorgan	Foxrock Church to Leeson Street	29:00	41:22	42.6%
Malahide	Greencastle Rd to Amiens Street	23:57	30:39	28.0%
Rathfarnham	Rathfarnham to Camden Street	22:11	25:38	15.5%
Lucan	Foxhunter to Bachelors Walk via Chapelizod Bypass	31:55	36:31	14.4%
Tallaght	West of M50 to Camden Street	39:43	45:11	13.8%
Swords	Cloghran Roundabout to Dorset St Lower	44:41	45:08	1.0%
Blanchardstown	Blanchardstown Bypass to North Circular Road	28:51	27:56	(3.2%)
North Clondalkin	Coldcut Road to Cornmarket	29:41	23:27	(21.0%)

FIGURE 29 Travel time savings by BBS for major travel corridors in Dublin, Ireland.

QBC Monitoring : Nov 1997- Nov 2003				
Cars Crossing Canal Cordon by Corridor	0700 - 1000			
BAC Buses Crossing Canal Cordon by Corridor	0700 - 1000			
BAC Bus Passengers Crossing Canal by Corridor	0700 - 1000			
Corridor	**Mode**	**Nov-97**	**Nov-03**	**% Change**
Stillorgan	CARS	5794	3323	-42.65
	BUSES	40	128	220.00
	BUS PAX	1787	6058	239.00
Blanchardstown	CARS	5963	5561	-6.74
	BUSES	83	136	63.86
	BUS PAX	4573	6668	45.81
Lucan	CARS	6104	5393	-11.65
	BUSES	71	106	49.30
	BUS PAX	4303	6759	57.08
Finglas / Swords	CARS	5678	5000	-11.94
	BUSES	112	133	18.75
	BUS PAX	5670	7611	34.23
North Clondalkin	CARS	1555	1405	-9.65
	BUSES	46	46	0.00
	BUS PAX	2079	2879	38.48
Malahide	CARS	4620	1599	-65.39
	BUSES	133	155	16.54
	BUS PAX	4747	9116	92.04
Tallaght	CARS	3314	2237	-32.50
	BUSES	72	94	30.56
	BUS PAX	4098	6318	54.17
Rathfarnham	CARS	3605	2704	-24.99
	BUSES	76	56	-26.32
	BUS PAX	3285	3631	10.53
Total	CARS	36633	27222	-25.69
	BUSES	633	854	34.91
	BUS PAX	30542	49040	60.57

FIGURE 30 Number of buses and passengers for key travel corridors in Dublin, Ireland.

Special Road Traffic Legislation (Road Traffic Act) was required to implement the BBS operations. Special enforcement efforts were made during the early years of operation; however, motorist abuse has declined to a very low level. Some excessive speeding by bus drivers has occurred. Bus drivers are given special training on the use of shoulder lanes.

Roundtable planning efforts involving the police, design office, bus operator, and the Dublin Transportation Office were instrumental in implementing the BBS operations. A special design office was established to roll out the bus network, including the hard shoulders projects.

CHAPTER FOUR

CONCLUSIONS AND FURTHER RESEARCH

Bus use of shoulder operations have been working successfully for more than a decade in several locations. They have been implemented in a variety of forms for a variety of purposes, but they appear to have a number of common traits. Bus bypass shoulder (BBS) applications minimize congestion-related schedule reliability problems, improve the competitive travel times for buses versus cars, are low cost and easy to implement, do not require new rights-of-way, and are not visually obtrusive. The early BBS projects appear to have been implemented without rigorous analysis and their success is reflected in the absence of post-project evaluation reviews and also by the expanding list of BBS projects. If accidents had proven to be a problem, safety evaluations would likely have been conducted and some BBS projects might have been abandoned. The few very short segments of BBS that have been abandoned are understood to have been upgraded to full bus lane operations. Indeed, the BBS practice is expanding, particularly in communities that have established BBS experience. Georgia has recently joined the list of states with BBS operations, California has implemented a pilot project, and Florida is scheduled to begin limited BBS operations. BBS's context-sensitive design features (low visual impact), low cost, ease of implementation, and support of more efficient and attractive transit services are features that resonate with numerous public policies.

The BBS concept also appears to be popular with bus passengers, who enjoy the feeling of preference as their bus moves past stop-and-go traffic in the general purpose traffic lanes. It is not uncommon for passengers to suggest to bus drivers that they move onto the shoulder when traffic begins to slow. Their perceived travel time benefits are generally greater than actual, but because perception is a key factor in affecting travel choices and increasing transit market share it is very important.

Although the bus use of shoulders is not an ideal highway/traffic operations concept, its 10-year-plus operations history in the Minneapolis metropolitan area indicates that it can be implemented relatively effectively and safely. The Twin Cities BBS application is a very low-cost effort with respect to pavement markings and signage, yet this low level signage and markings operation has proven to be safe.

Actual data on operations and patronage benefits is sketchy for established BBS operations, as are the processes used to implement the shoulder use projects. Newer BBS project implementations are tending to be more rigorous and to provide a detailed record of the policy and analytical processes. Implementation of these new projects will prove useful at providing a more quantitative understanding of BBS.

A cooperative or partnership approach involving transit operations, departments of transportation, police, and metropolitan planning organizations appears to be crucial in planning, implementing, and operating BBS projects.

Of the study objectives of this synthesis report, data on many of the issues were either not readily available or not available at all. Better information would be useful to communities considering implementation of BBS and those interested in improving current BBS projects. It might also be valuable for "New Starts" project alternative definitions and evaluations. Information on early BBS projects is primarily limited to what can be observed on the highways. Little history exists on the institutional, legal project development process, costs, and performance of these early BBS projects. This important information is becoming available for the more recent and the planned projects (i.e., Georgia 400, planned Miami–Dade BBS, and San Diego BBS).

What is clear is that the an increasing number of communities are pursuing shoulder use projects and that an implementation checklist and a TCRP document similar to that prepared for *TCRP Report 90: Bus Rapid Transit*, might be useful.

Key issues warranting further research are:

- What are the market and patronage benefits associated with BBS and how can project design maximize these benefits? Surveys might be useful to better understand passenger perceptions as well as the perceptions of motorists using the adjacent general purpose lanes. Understanding the perceptions of these groups might help to design better BBS projects as well as provide guidance to marketing efforts. Quantification of before and after patronage in corridors is also needed.
- What are the bus running time and reliability benefits resulting from BBS operations? Tracking bus service performance using global positioning systems could help to quantify operational benefits. A survey of bus drivers could complement the global positioning system monitoring program and provide added insights

into program benefits and opportunities to enhance the BBS concept.

- What is the safety history of BBS operations and how might the design of BBS applications minimize safety risks? From a review of accident data and discussions with enforcement and driver training and bus safety staff, key safety concerns and myths might be described.
- Most of the BBS projects that have been implemented employed a multi-agency team planning, design, and implementation approach. More information is required on these multi-agency partnership efforts, as well as legal aspects of project implementation.
- What geometric improvements are needed and what are their guidelines for costs? The minimum widths need further definition. Should shoulders be wider on bridges and underpasses and other segments with horizontal obstructions nearby? Is there a maximum distance that minimum width shoulders are tolerable? Should shoulders be wider at sharp curves? What are desired geometrics for BBS transitions and interchange ramp weave areas? What is the minimum pavement strength required? How important are modifications to drainage inlets? What are the desired and maximum drainage cross slopes for BBS shoulders? What lighting improvements, if any, are desired for the BBS segments? What minimums can be accepted, particularly for interim applications?
- What signage and striping guidelines and standards are recommended and could these be included in the next update of the *Manual on Uniform and Traffic Control Devices*?
- How might variable or changeable message signs and ITS technologies be used to improve BBS safety?
- What speeds are safe for BBS operations and how do bus volumes and shoulder width dimensions influence safe speeds?
- What are the advantages and disadvantages of speed-limited BBS operations versus Ottawa's higher speed operations?

REFERENCES

1. *A Policy on Geometric Designs of Highways and Streets*, American Association of State Highway and Transportation Officials, Washington, D.C., 2004, 940 pp.
2. *Manual of Uniform Traffic Control Devices for Streets and Highways*, Federal Highway Administration and American Association of State Highway and Transportation Officials, Washington, D.C., 2003.
3. Curren, J.E., *NCHRP Report 369: Use of Shoulder and Narrow Lanes to Increase Freeway Capacity*, Transportation Research Board, National Research Council, Washington, D.C., 83 pp.

APPENDIX A

Screening Questionnaires

Two survey questionnaires were employed for this synthesis project. A brief questionnaire was designed to identify existing and planned use of bus shoulder applications. It also solicited areas of concern from this broad group of agencies surveyed. The longer survey questionnaire was only sent to those agencies that indicated having an existing or near-term planned bus use application. The two-phase survey approach was intended not to burden agencies that do not have shoulder use applications with irrelevant questions and thereby discourage response to the initial screening questions.

The screening survey was distributed using commercial web-based software—"Survey Monkey" (see Figure A1 for description of Survey Monkey). The longer and more detailed follow-up survey was distributed as a word document by means of e-mail. This second survey format lends itself to more flexible responses for those agencies with more than one bus use of shoulder application.

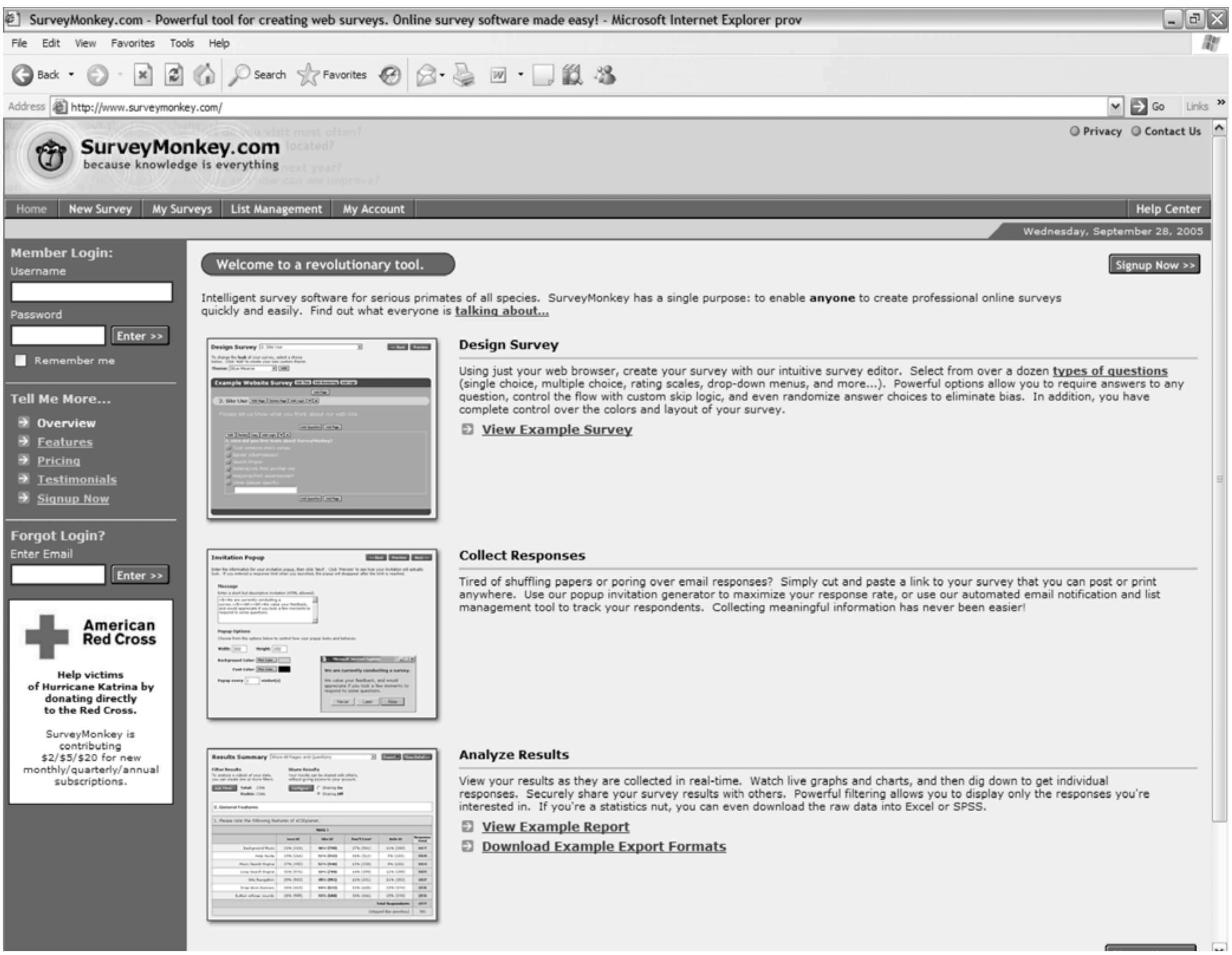


FIGURE A1 Description of Survey Monkey software from SurveyMonkey.com website.

TRANSIT COOPERATIVE RESEARCH PROGRAM

SYNTHESIS TOPIC SD-03

Congestion Bypass Use of Shoulders

Questionnaire (screening)

Project Purpose—In many urban areas, traffic congestion commonly delays bus services and adversely impacts schedule reliability. Some communities have adopted policies and regulations that permit buses to use arterial or freeway shoulders to bypass congestion either as interim or long-term treatments. Maryland, Virginia, Minnesota, Washington, British Columbia, and Ontario are among the jurisdictions that have implemented or are considering implementing bus use of shoulder programs. California is presently considering the bus use of shoulders concept, and a number of communities allow general traffic use of shoulders during peak periods. Many jurisdictions, however, have been reluctant to embrace bus use of shoulders for various reasons. Little information is available about travel time, reliability, patronage benefits, and safety impacts resulting from allowed use of shoulders.

Purpose of Survey—The two primary purposes of this synthesis are: (1) to identify and obtain information about jurisdictions that allow bus use of shoulders, along with positive and negative experiences, and (2) to identify and obtain information about what jurisdictions have considered, but have not implemented, these treatments and the reasons why. Both the transit and highway perspectives will be explored, recognizing that both must be partners in expanding promising applications for increasing patronage and improving operating efficiency. General traffic use of shoulders experience is also of interest as it provides useful and relevant insights for bus use applications.

Agencies that are involved with shoulder use applications will be contacted later for further information.

General Information on the DOT/Transit Agency/MPO

Agency Name: ______________________________
Address: ______________________________
City: ______________ State/Province: ______________ Postal Code: __________
Contact Name/Title: ______________________ Date: ______________
Telephone: ______________ Fax: ______________ E-Mail: ______________

1. Are shoulder lanes of highways in your jurisdiction currently open for buses to use in order to bypass traffic congestion?
( ) Yes ( ) No
If yes, please specify locations ______________________________
____
____

2. In the past, had buses been allowed to use highway shoulders to bypass congestion?
( ) Yes ( ) No
If yes, specify locations ______________________________

3. Are the use of highway shoulders by buses now currently under review?
( ) Yes ( ) No

4. Are general traffic or HOVs allowed to use shoulders during peak hours?
( ) Yes ( ) No
If yes, please specify location ______________________________

5. Does the bus shoulder congestion bypass concept seem to offer promise in your jurisdictional area and if so what highway segments might benefit from this concept? ______________________________

6. What types of concerns would you have regarding the design, operation, and implementation of the bus shoulder congestion bypass concept? ______________________________

7. Are you aware of any states or provinces other than those mentioned in the opening paragraph that permit buses to use highway shoulders to bypass congestion? If so please list. ______________________________

8. Suggested contacts at agencies involved with your shoulder use project (DOT, Bus Operator, MPO, etc.)
____

9. Other suggested references and sources: ______________________________

Additional comments: ______________________________

Thank you in advance for assisting us with the project. Should you have any questions, please contact me at the address below.

Please complete and return this questionnaire by the end of January to:

Peter Martin
Wilbur Smith Associates
201 Mission Street, Suite 1450
San Francisco, CA 94105

Phone: 415-495-6201
E-mail: pmartin@wilbursmith.com

Detailed Survey for Bus Use of Shoulder Agencies

TRANSIT COOPERATIVE RESEARCH PROGRAM

SYNTHESIS TOPIC SD-03

Congestion Bypass Use of Shoulders

Questionnaire

Who Should Complete the Survey—Recently you completed a short screening survey that was designed to identify current bus use of shoulders projects in North America. We understand from the screening survey that __________ has a bus use of shoulders application for ____________________________. The attached questionnaire seeks to learn more about this application. Your assistance with this detailed survey effort is much appreciated. If the answer is unknown please indicate and continue with the completion of the survey. It is a word document, so please fell free to add space as needed.

Project Purpose—In many urban areas, traffic congestion commonly delays bus services and adversely impacts schedule reliability. Some communities have adopted policies and regulations that permit buses to use arterial or freeway shoulders to bypass congestion either as interim or long-term treatments. Maryland, Virginia, Minnesota, Washington, British Columbia, and Ontario are among the jurisdictions that have implemented or are considering implementing bus use of shoulder programs. Many jurisdictions, however, have been reluctant to embrace bus use of shoulders for various reasons. Little information is available about travel time, reliability, patronage benefits, and safety impacts resulting from allowed use of shoulders.

The purposes of this synthesis are (1) to identify and obtain information about jurisdictions that allow bus use of shoulders, along with positive and negative experiences, and (2) to identify and obtain information about what jurisdictions have considered, but have not implemented these treatments and the reasons why. Both the transit and highway perspectives will be explored, recognizing that both must be partners in expanding promising applications for increasing patronage and improving operating efficiency.

General Information on the DOT/Transit Agency/MPO

Agency Name: ____

Address: ____

City: ____________________ State/Province: ________________ Postal Code: __________

Contact Name/Title: ______________________________ Date: ____________________

Telephone: ____________________Fax: ________________ E-Mail: __________________

Shoulder Use Location and Features

1. Which segment and direction? ____

____

2. Are bus operating speeds restricted for shoulder use?

( ) Yes—please specify maximum speed(s) __________

( ) No

3. How many one-way miles of shoulders are buses allowed to use in order to bypass congestion?
____ miles

4. When were the shoulders open to bus usage? _____month _____ year

5. Are any special operating procedures or instructions given to the bus drivers using the shoulders?
( ) Yes—please describe or append instructions: ____
____
____
( ) No

6. Is any special training provided for bus operators using shoulders?
( ) Yes—please describe: ____
____
____
( ) No

7. Who is permitted to use the shoulder lanes—only public transit buses, all buses, HOVs?
( ) Only public buses
( ) Any bus
( ) HOVs
( ) All traffic including private cars

8. Are the shoulders only used for peak direction of travel or both directions?
( ) Peak direction only
( ) Both directions

9. What are the hours of operation?
Morning—from _____ a.m. to _____ a.m.
Evening—from _____ p.m. to _____ p.m.

10. Are these hours of operation fixed or linked to congestion?
( ) Fixed
( ) Linked to congestion levels—describe how: ____

11. Is shoulder use also allowed on weekends as well as weekdays?
( ) Yes
( ) No

12. What companies and routes use the shoulders and what are their headways during should use hours?
Transit Agency(s) and routes: ____
____
____

13. Estimate of how many buses use the shoulders on an average weekday?
______ morning peak
______ evening peak

Surveyed User Benefits and Costs

14. Have you conducted any surveys of bus passengers to ascertain their opinions about the buses using shoulders?
( ) Yes
( ) No

15. If so, could you please summarize/forward the results of these surveys? ____________________________
____
____

16. Have you surveyed bus drivers for their opinions and ideas for improving the application?
( ) Yes
( ) No

If so, please summarize or forward a copy of results. Informal debrief information would also be appreciated. ____
____
____

17. Are ITS technologies used on-board the buses and/or alongside the highway to support shoulder use and if so what are they and what are their purposes?
( ) Yes—please describe: ____
( ) No

18. What improvements to the pavement, signage, etc., were required to allow buses to use the shoulders and what were the costs of these improvements? (Please indicate if the cost is an approximation or actual costs.) ____
____
____

19. How have snow removal, enforcement efforts, disabled vehicle, and accident removal needs been affected by the shoulder use? ____
____
____

20. Are the shoulders used for regular traffic during pavement maintenance and other highway improvement efforts and if so how has this been coordinated with bus use of shoulders? ________________
____

21. What is your estimate of the added annual highway maintenance and operations costs related to the bus use of shoulders? $ _____________ per year. What were the major cost increases related to? ____________
____

22. What bus operations savings do you estimate have resulted from buses using shoulders to bypass congestion? (If added cost rather than savings please indicate.) ______________________________
____
____

<u>Measured Benefits and Costs</u>

23. Were before and after bus operating speeds surveyed during shoulder usage hours conducted and if so what were the before and after bus operating speeds? Before ______mph, after ______ mph

24. For each shoulder use application what are the typical travel times during peak congestion periods for buses______________ minutes, for cars _____________ minutes

25. Were before and after schedule reliability studies conducted and if so what were the results?
Before ____
After ____

26. What has been the accident experience of the shoulder operation (number and type)? ________________
____
____

27. What affect have the shoulder operations had on bus patronage? ________________________________
____
____

28. Have the shoulder use operations impacted operations on the regular traffic lanes or at ramps?
( ) Yes—please explain: ____
( ) No

Highway Design and Upgrade Needs (input from highway agencies welcomed)

29. Are new or upgrades to shoulders constructed to full traffic lane standards of width and pavement strength?
( ) Yes
( ) No

30. What is the minimum width of shoulder used by buses to bypass congestion? _______ feet

31. What were the pavement design standards used for bus bypass shoulders? __________________________
____

32. How many on- and off-ramp conflict points are there along the shoulder use segment?
_____ on-ramps
_____ off-ramps

33. What special markings are used for the bus use shoulders? ______________________________________

34. What special signage is used for the bus use shoulders at termini, at ramp conflicts points, and along the highway in general? ____
____
____

35. What special modifications were made if any for drainage? ______________________________________
____

Enforcement Experience and Lessons Learned

36. What special enforcement efforts were implemented? ____
____

37. How many warnings and citations have been issued for misuse of the shoulders and has the abuse rate declined over time? ____

38. Have there been abuse of the shoulder use privileges by bus operators?
( ) Yes
( ) No
What type? ____

39. Have cameras or other ITS measures been employed for enforcement?
( ) Yes
( ) No
Describe measures: ____

Implementation Background and Issues

40. What led to the implementation of shoulder use for buses to bypass congestion—specific problem, opportunity, or advocate? ___

41. Please describe the planning process and agencies involved. ___

42. What special design coordination if any was involved to implement the bus use of shoulders?

43. What process was employed to implement the shoulder use? ___

44. What special efforts and procedures are employed for on-going maintenance and operations coordination? ___

45. Was special legislation required or was the shoulder use program implemented by administrative action? ___

Please describe: ___

46. Were changes made to the vehicle code or other regulations?

( ) Yes, please explain: ___

( ) No

47. Has the shoulder use program increased, reduced, or had no impact on public liability?

( ) Increased, please explain: ___

( ) No impact

( ) Reduced, please explain: ___

48. Suggested contacts at agencies involved with your shoulder use project (DOT, Bus Operator, MPO, etc.). ___

49. Other suggested references and sources: ___

Assessment of Overall Success

What is your understanding of the acceptance (success/neutral/opposed) of the shoulder use concept by

Transit operator___

State DOT___

Bus drivers___

Community in general___

What have been the key lessons learned? ____
____
____

Report Materials

If reports, graphic descriptions, and photographs are available they would be very useful and appreciated. Please transmit them along with the questionnaire. Please indicate credits, etc., that should be used if they are republished as part of our report. Materials will be returned immediately after review.

Closure Information

Other suggested relevant information: ____
____
____
____

Additional comments: ____
____
____

Thank you in advance for assisting us with the project. Should you have any questions, please contact me at the address below.

Please complete and return this questionnaire to:

Peter Martin
Wilbur Smith Associates
201 Mission Street, Suite 1450
San Francisco, CA 94105

Phone: 415-495-6201
E-mail: pmartin@wilbursmith.com

APPENDIX B

Survey Respondents

Arizona
Maricopa Association of Governments, Phoenix
Pima Association of Governments, Tucson

California
Caltrans District 11
Central Contra Costa County Transit Authority, Concord
Golden Empire Transit, Bakersfield
Kern Council of Governments, Bakersfield
Metropolitan Transportation Commission, San Francisco Bay Area
Monterey—Salinas Transit
San Diego Association of Governments (SANDAG)
Santa Barbara Council of Governments
South Coast Area Transit, Oxnard

Colorado
Denver Regional Council of Governments
North Front Range Metropolitan Planning Organization, Fort Collins

Connecticut
Capitol Region Council of Governments, Hartford
State Department of Transportation

Delaware
Delaware Transit Corporation
State Department of Transportation

Florida
Florida Turnpike Enterprise
Metroplan, Orlando
State Department of Transportation

Georgia
Georgia Regional Transportation Authority
State Department of Transportation

Hawaii
Oahu Metropolitan Planning Organization

Illinois
State Department of Transportation

Indiana
Indianapolis Public Transportation Corporation

Iowa
State Department of Transportation

Kansas
State Department of Transportation

Kentucky
Kentuckiana Regional Planning and Development Agency, Louisville

Louisiana
Capitol Region Planning Commission, Baton Rouge
State Department of Transportation

Maine
State Department of Transportation

Maryland
State Transit Administration

Michigan
Tri-County Regional Planning Commission, Lansing

Minnesota
Metro Transit, Minneapolis

Mississippi
State Department of Transportation

Missouri
Mid-America Regional Council, Kansas City
State Department of Transportation

Montana
State Department of Transportation

Nebraska
Department of Roads

Nevada
Regional Planning Commission of Southern Nevada, Las Vegas

New Hampshire
State Department of Transportation

New Jersey
Motor Vehicle Commission
New Jersey Transit Corporation
State Department of Transportation

New York
State Department of Transportation

<u>North Carolina</u>
Charlotte Transit

<u>Ohio</u>
Metro Regional Transit Authority, Akron
Northeast Ohio Areawide Coordinating Agency, Cleveland

<u>Oregon</u>
State Department of Transportation

<u>Pennsylvania</u>
Southeastern Pennsylvania Transit Authority (SEPTA)

<u>Rhode Island</u>
State Department of Transportation

<u>South Carolina</u>
Central Midlands Council of Governments, Columbia
State Department of Transportation

<u>Tennessee</u>
Knoxville Regional Transportation Planning Organization
State Department of Transportation

<u>Texas</u>
Houston Galveston Area Council
State Department of Transportation

<u>Utah</u>
State Department of Transportation
Wasatch Front Region Council, Salt Lake City

<u>Virginia</u>
Hampton Roads Planning District Commission
State Department of Transportation

<u>Washington</u>
Central Puget Sound Regional Transit Authority, Seattle
Pierce Transit, Tacoma
Southwest Washington Regional Transportation Council, Vancouver
State Department of Transportation

<u>West Virginia</u>
State Department of Transportation

<u>Ontario</u>
Ottawa
GO Transit, Toronto
Toronto Transit Commission

<u>British Columbia</u>
Translink Vancouver
Victoria Regional Transit System

In addition to the survey respondents that are listed here, a number of other agencies were contacted by phone to follow suggested leads. These telephone inquires included the Massachusetts Highways, Boston Central Transportation Planning Staff, and Miami–Dade Transit.

APPENDIX C

Supporting Materials from Case Studies

C1 Minnesota Enabling Legislation
C2 Minneapolis Shoulder Use Operating Rules
C3 Virginia Operating Agreement Regarding Bus Use of Shoulders
C4 Miami–Dade County Metropolitan Planning Organization Special Use Lane Study Phase II: Scope of Services
C5 Miami–Dade County Shoulder Use Listing of Key Concerns
C6 Toronto, Ontario, Bus Driver Training Presentation

C1 MINNESOTA ENABLING LEGISLATION

Sec. 10. [169.306] [Use of shoulders by buses]

(a) The commissioner of transportation may permit the use by transit buses and metro mobility buses of a shoulder of a freeway or expressway, as defined in section 160.02, in the seven-county metropolitan area.

(b) If the commissioner permits the use of a freeway or expressway shoulder by transit buses, the commissioner shall also permit the use on that shoulder of a bus with a seating capacity of 40 passengers or more operated by a motor carrier of passengers, as defined in section 221.011, subdivision 48, while operating in intrastate commerce.

(c) Buses authorized to use the shoulder under this section may be operated on the shoulder only when main line traffic speeds are less than 35 miles per hour. Drivers of buses being operated on the shoulder may not exceed the speed of main line traffic by more than 15 miles per hour and may never exceed 35 miles per hour. Drivers of buses being operated on the shoulder must yield to merging, entering, and exiting traffic and must yield to other vehicles on the shoulder. Buses operated on the shoulder must be registered with the Department of Transportation.

C2 MINNEAPOLIS SHOULDER USE OPERATING RULES

BUS-ONLY SHOULDER
OPERATING RULES
FOR TRANSIT BUSES

Only public transit buses may use the shoulders, and then only during the posted hours. Here are some operating rules you need to know. They were formulated with the approval of the State Highway Patrol, and are designed to ensure safe operation. **Please abide by these rules. If there are accidents involving your bus and the shoulder lanes, it could cause the privilege to be taken away.**

1. Use shoulder lanes <u>only</u> when and where signs permit. Be aware, however, that the bus lanes are continuous through right turn lanes, through intersections and through entrance and exit ramp merges. It is <u>not</u> necessary to merge back into regular traffic at these locations.

2. If traffic is stopped, buses should not exceed 15 mph.

3. If traffic is moving, bus speed should be no more than 15 mph faster than the traffic, **<u>up to a maximum of 35 mph</u>**.

4. If traffic is moving 35 mph or faster, buses must operate in the regular traffic lane.

5. Operate slowly and cautiously when there is snow, ice or water on the road.

6. Always yield to cars entering the shoulder lane. Remember that you are in the best position to avoid an accident. If a car is stalled on the shoulder, merge back into traffic and go around it.

7. The Highway Patrol encourages you to turn on your four-way flashers and use your horn to alert motorists. Use your best judgment.

C3 VIRGINIA OPERATING AGREEMENT REGARDING BUS USE OF SHOULDERS

November 7, 2000

Mr. XXXX,
XXXX County Executive
Address 1
Address 2, Virginia 22035

Re: Dulles Airport Connector Road; right emergency shoulder
Magarity Road to West Falls Church Metrorail Station off-ramp
Use of Shoulder by Transit Buses

Dear Mr. Griffin,

This letter outlines the common understanding between VDOT and Fairfax County regarding the principles for use of the eastbound Dulles Airport Connector Road widened shoulder by Fairfax Connector buses headed to the West Falls Church (WFC) Metro Station, as requested by Fairfax County letter dated November 6, 1998.

a. Purpose of Measure, Applicability, Conditions for Use by Buses:

The purpose of the measures is to allow transit buses headed to the WFC Metro Station to bypass other traffic and thus avoid delays. Use of the shoulder by buses shall be limited to periods of traffic congestion (generally defined as when mainline speeds are 25 mph or less), during the days/times listed in **b** below. The following conditions shall apply:

- The primary use of the shoulder is for emergencies. Buses may only use the shoulder when it is safe to do so. If a driver becomes aware (by observation or through notification by others) that the shoulder is being used by a disabled, stopped, or emergency vehicle, he/she shall not use the shoulder west of the incident. Shoulder shall not be used when snow or ice conditions make its use unsafe.
- Bus drivers are asked to refrain from entering the shoulder if they become aware of an emergency or incident along the mainline which, in their judgment, may require imminent use of the shoulder by emergency vehicles.

b. Days and Times of Use:

Shoulder use is permitted Monday through Friday during the following times:
4:00 p.m. to 8:00 p.m.

c. Shoulder Use Location:

Authorized buses may use the eastbound Dulles Airport Connector Road widened shoulder from east of the Magarity Road overpass to the ramp leading to the WFC Metro Station, where appropriate signs are installed (approx. distance: 1.3 miles).

d. Authorized Buses:

Only public transit buses going to the WFC Metro Station shall be allowed to use the shoulder.

e. Operations and Responsibilities:

It is the responsibility of the bus driver to: keep the bus's headlights on at all times while on the shoulder; maintain a safe driving speed not to exceed 25 mph, notify the dispatcher if he/she becomes aware of a negative condition restricting use of the shoulder (referred to in **a** above).

It is the responsibility of the dispatcher to notify his/her bus drivers of any negative conditions restricting use of the shoulder that he/she becomes aware of.

f. Training:

All bus drivers assigned to this route should have appropriate safety training for this specific shoulder operation as outlined in this letter.

g. Administrative Procedures and Communications:

Fairfax County will periodically install a monitoring device in the pavement of the shoulder in order to gather data on its use, and will forward the information collected to VDOT. VDOT and the transit operators authorized to use the shoulder shall meet periodically, at the request of either agency, to evaluate the performance and use of the shoulder.

Thomas F. Farley, VDOT NOVA District Administrator Date

XXXX, XXXX County Executive

C4 MIAMI–DADE COUNTY METROPOLITAN PLANNING ORGANIZATION

SPECIAL USE LANE STUDY PHASE II
SCOPE OF SERVICES

I. OBJECTIVE

To develop a bus service implementation plan for the Express Core System as recommended in Phase I of this study. This second phase will include detailed analyses for implementing express service along the Turnpike, SR-826 (Palmetto Expressway), and SR 836 (Dolphin Expressway).

II. PREVIOUS WORK

In the First Phase of this study a two-tier approach was conducted to evaluate congested corridors in Miami–Dade County. In Tier I, sixteen (16) corridors were evaluated using nine (9) criteria to determine those for consideration in Tier II. As a result, 9 corridors were evaluated in detail for improvements. These corridors were: I-95, SR-826, SR-836, Biscayne Boulevard, Flagler Street, Kendall Drive, NW 27th Avenue, LeJeune Road, and Douglas Road. Among the alternatives considered for implementation was the establishment of: reversible lanes, HOV lanes, Zipper lanes, and Bus Rapid Transit (BRT), among others.

As a result two scenarios were recommended for further analyses:

1. Express Core System
   This scenario recommends the implementation of express bus services along the Homestead Extension of Florida's Turnpike (HEFT), SR-826, and SR-836. This recommendation includes the use of the roadway shoulders for these services. Additionally, a recommendation is also made to improve transit services along Kendall Drive to provide a connection between the Turnpike, SR-826, and Metrorail.
2. Arterial Core System
   This scenario proposes the development of BRT along Flagler Street and Biscayne Boulevard.

III. BACKGROUND

When this study was originally developed, it was divided into two phases. The First Phase would identify the corridors and strategies for implementation, while the Second Phase will produce detailed plans for implementation (if needed).

The total cost of the First Phase was $64,750.00 and it was completed on schedule in ninety (90) days. Based on the recommendations made in the study, a meeting was scheduled to discuss these results. Two meetings were held with the participation of the Turnpike Enterprise, Florida Department of Transportation (FDOT) District 6, Miami–Dade Transit (MDT), Miami–Dade Expressway Authority (MDX), Public Works Department (PWD), the Metropolitan Planning Organization (MPO), and the consultant.

At a meeting of all interested parties and after evaluating both scenarios it was decided to proceed with a more detailed analysis focusing on the Express Core Scenario. This will require exploring how to implement express bus use of shoulder lanes on the recommended expressways. Additionally, the MPO will prepare a Scope of Work (SOW) to continue with the Second Phase of the study as indicated in the original SOW and approved by Resolutions TPC #15-04 and MPO #18-04, but addressing only this element of the Special Use Lane Study.

IV. METHODOLOGY

A. *TASK 1: Perform Study Administration*

1. Set the study schedule.
2. Establish close coordination with MDT, FDOT District 6, MDX, the Turnpike Enterprise, and the PWD. The MPO Project Manager will assemble a Study Advisory Committee (SAC), if needed. The representatives of these agencies and others as appropriate will review and comment on study documents, and provide input on study findings and recommendations.
3. Conduct/attend meetings.
   - **a.** Prepare progress reports as appropriate.
   - **b.** Conduct meetings as appropriate to discuss the progress of the study.
   - **c.** Conduct presentations for the standing committees associated with the study (6 presentations).

B. *TASK 2: Perform Background Research*

1. Review literature regarding use of shoulders for public transit along expressways in other cities. The consultant should contact:
   - **a.** The Minnesota DOT to obtain additional information regarding the use of shoulders for public transit. In Minneapolis, the transit agency has been using this strategy for over 10 years. This information should include the following aspects, among others:
     - Transit operations
     - Highway operations
     - Legal issues
     - Engineering
     - Safety (signage and record of accidents)
     - Enforcement
     - Funding.
   - **b.** FHWA and FTA to obtain information regarding requirements and regulations that will allow the use of the shoulders for public transit along expressways.
   - **c.** FDOT District 6, the Turnpike Enterprise, MDX, MDT, and the Miami–Dade PWD to obtain information regarding their concerns in implementing this strategy, as well as existing regulations for using the shoulders.

2. Additionally, the consultant should contact other state agencies that may regulate public transit services.
3. Finally, the consultant should research state statutes that may prevent or limit the use of shoulders along expressways for public transit.

C. ***TASK 3: Legal Assistance***

Based on previous discussions, the involved parties concurred that legislation needs to be introduced at the state level to allow the use of shoulders for public transit along expressways. The consultant will assist the county and participating entities with technical information and legal support obtained in Task 2 to prepare the necessary documentation to introduce legislation for allowing the implementation of this project.

D. ***TASK 4: Data Collection***

1. The consultant will coordinate with the involved entities in obtaining current traffic and roadway data along SR-826 (Palmetto Expressway), SR-836 (Dolphin Expressway), the Homestead Extension of Florida's Turnpike (HEFT), and I-75, within the boundaries of the proposed transit services as shown in the attached exhibits.
2. Additionally, it is requested that the same information be obtained for the I-95 (from SR-112 to downtown). The purpose of this information is to evaluate the possibility for improving the existing MDT service from Golden Glades to downtown by using the shoulders from SR-112 to downtown Miami.
3. The consultant will also conduct field inspections along these corridors to obtain necessary data for implementing the proposed services.
4. These data will include, but not be limited to:
   - **a.** Traffic volumes
   - **b.** Level of service (LOS)
   - **c.** Number of lanes
   - **d.** Lane width
   - **e.** Number of accidents
   - **f.** Access ramps
   - **g.** Pavement markings
   - **h.** Height requirements
   - **i.** Lighting
   - **j.** Existing signage
   - **k.** Weaving distance
   - **l.** Availability of park and ride facilities
   - **m.** Potential locations for limited stops, if finally recommended
   - **n.** Shoulders
     - Shoulder width
     - Pavement type and thickness
     - Pavement condition
     - Cross slope
     - Continuity of shoulders

- Numbers of potential obstructions (ramp entrances and exits, bridges, etc.)
- Rumble strips.

E. ***TASK 5: Data Analysis***

The consultant will evaluate all aspects listed below along the corridors that may impact positively and negatively the operation of the proposed express bus routes.

1. Engineering Issues

The consultant will evaluate all engineering aspects along the corridors as indicated in Task 4.

2. Traffic Impacts

The consultant will determine current and future impacts of traffic conditions, including traffic volumes, LOS, travel delays, and travel time, among others.

3. Transit Operation

The consultant will determine current and future potential ridership of the proposed express services.

4. Safety Conditions

The consultant will identify conflictive locations along the corridors where accidents could affect the implementation of the service.

F. ***TASK 6: Development of Conceptual Alternatives***

Based on the results of the previous tasks, the consultant will develop conceptual plans for each service listed below. The plans shall include signage, enforcement, and incident management for each service.

1. SR-826 (Palmetto Expressway)

- **a.** Dadeland South Metrorail Station to Westland Mall
  - Evaluate potential extension to Miami Lakes
  - Access to end terminals
  - Access to Palmetto Metrorail Station
  - Connection to Bird Road.
- **b.** Kendall Drive/Turnpike/SR-836 (Dolphin Expressway)
- **c.** West Kendall to the Miami International Airport/MIC
- **d.** West Kendall to downtown
- **e.** West Kendall to downtown via the Dolphin Mall/International Mall
- **f.** Dolphin Mall/International Mall to the Miami International Airport/MIC
- **g.** In all these routes consultant should check:
  - Access to end terminals
  - Locations for end terminals
  - Connections to Bird Road and FIU
  - Potential problems along Kendall Drive, NW 107th Avenue, and LeJeune Road regarding traffic and transit operations, as well as physical conditions that may deteriorate the service.

2. West Broward to Miami–Dade via Palmetto Expressway

- **a.** Evaluate change in the proposed route alignment
  - Pembroke Lakes Mall to and from the Palmetto Metrorail Station via Flamingo Road and the Palmetto Expressway

- Pembroke Lakes Mall to and from the Palmetto Metrorail Station via I-75, Miami Gardens Drive, Ludlum Road, and the Palmetto Expressway
- Pembroke Pines west on I-75 on Pines Boulevard to Palmetto Metrorail Station.

b. Identify locations for end terminals

c. Connection to potential Park & Ride lot at Miami Gardens Drive.

3. Golden Glades to downtown via I-95
This route will consider using the shoulder from SR-112 to downtown Miami.

G. ***TASK 7: Action Plan***

The consultant will develop implementation plans for the proposed services along the Turnpike, SR-826, SR-836, I-75, and I-95. These plans will include, among other things:

1. Recommended service along the corridors.
2. Identification of potential locations where service can be disrupted due to physical impediments, safety issues, continuity of operation through entrance and exit ramps and toll plazas, etc.
3. Recommended engineering options as well as operating alternatives to solve the situations identified in the conflictive locations listed previously.
4. Time schedule.
5. Estimated cost.

Additionally, the plan should include details of actions to be accomplished regarding changes in state laws, signage, operational changes, operator training, public involvement, education of automobile drivers, etc. The recommended time frame should take into considerations MDT's plan to initiate service with buses operating in mixed traffic by April 2005.

H. ***TASK 8: Prepare Final Report***

The consultant will prepare a comprehensive final report summarizing all activities conducted in the study. This will include illustrations, pictures, and sketches of the current conditions and proposed actions.

V. STUDY DELIVERABLES

A. Twenty (20) copies of the Final Report (full color). Pictures, charts, diagrams, maps, and tables should be included to facilitate the reading and illustrate the results of the study.
B. One hundred (100) copies of the Executive Final Report (full color in a newsletter format and no more than 8 pages is recommended).
C. A Power Point presentation with the highlights of the study.
D. Any brochure or printed material that contributes to enhance the study.
E. Final Report and Executive Summary will be also submitted in electronic format (CD-ROM) for further reproduction and distribution.

VI. STUDY FUNDING

$75,000 (including 10% for contingency).

VII. TIME SCHEDULE

This is a 6-month study.

VIII. PROJECT MANAGER

Jesus Guerra

IX. PARTICIPANTS

A. MPO (lead agency)
B. Florida Department of Transportation (FDOT) District 6
C. Florida Turnpike Enterprise
D. Miami–Dade Expressway Authority (MDX)
E. Miami–Dade Public Works Department
F. Miami–Dade Transit (MDT)
G. And other entities as needed.

C5 MIAMI–DADE COUNTY SHOULDER USE LISTING OF KEY CONCERNS

Summary of concerns discussed among the participants in the project that needs clarification.

1. **Engineering Issues**

   a. Some sections of the shoulders along the referred facilities are paved for 10 feet and due to specific design criteria are not considered travel lanes. A travel lane of less than 12 feet is not considered without a written and approved design exception from the Florida Department of Transportation Central Office.
   b. The cross slope of the shoulders is not designed for travel lane use.
   c. The pavement structure of the shoulders is not compatible for travel lane use.
   d. The shoulder transitions from roadway to bridge and other structures are a deterrent to through bus movements.
   e. Use of the shoulder as a travel lane reduces the clear zone.
   f. Some sections of the shoulders along these facilities are lined with rumble strips that would fall in the wheel path of buses.

2. **Safety Issues**

   a. Shoulders are constructed for general vehicles to use in case of breakdown. Buses using the shoulder and encountering a parked vehicle would have to merge back into the travel lane reducing the level of service and increasing accident potential on a high speed facility.
   b. Shoulders are also used by police, fire, and emergency vehicles during incidents. Buses on the shoulder would again have to merge back into traffic during these periods.

3. **Legal Issues**

   a. There may be liability issues that would have to be considered by permitting buses to operate on a non-through lane structure.
   b. State law in Florida has to be amended to allow buses to utilize shoulders.

4. **Enforcement Issues**

   a. Permitting only buses to use shoulders for travel lanes while other vehicles are stopped or slowed may become an enforcement problem. If other drivers see a bus using the shoulder, what will prevent them from following the bus and compounding the problem? There are already occurrences of vehicles trying to use the shoulders to get around crash sites, which increases congestion.

Most of these issues along with others are included in the Scope of Work for discussion and solution.

C6 TORONTO, ONTARIO, BUS DRIVER TRAINING PRESENTATION

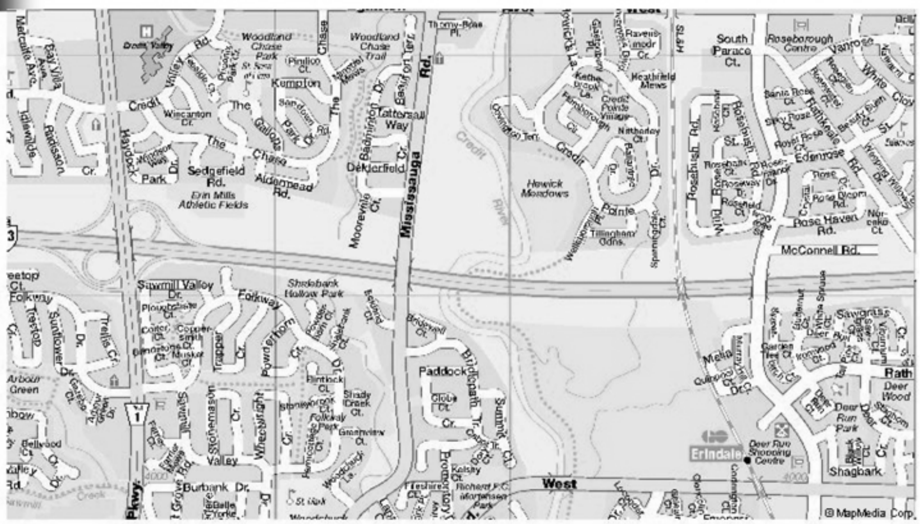
Bus Bypass Shoulder Operating Protocol

Highway 403 E/B and W/B
Between
Erin Mills Parkway and Mavis Road

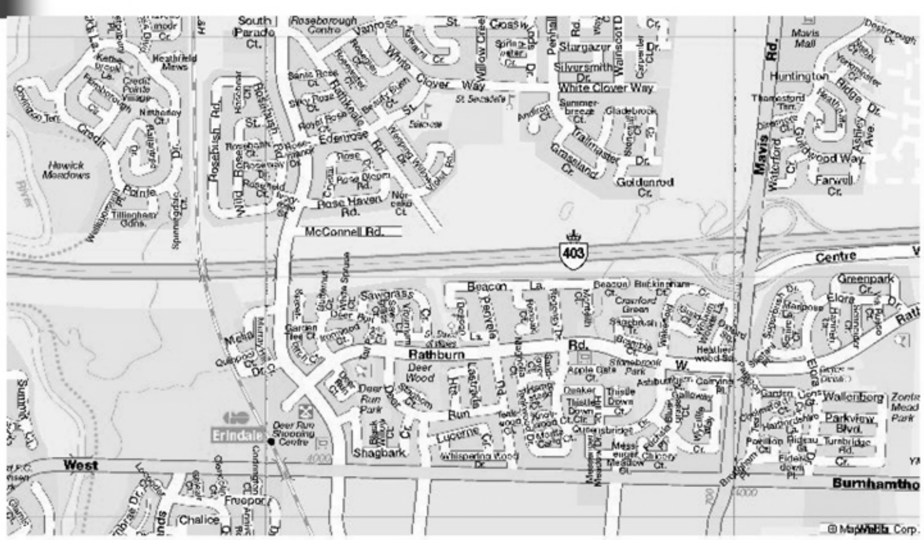
Seminar Outline

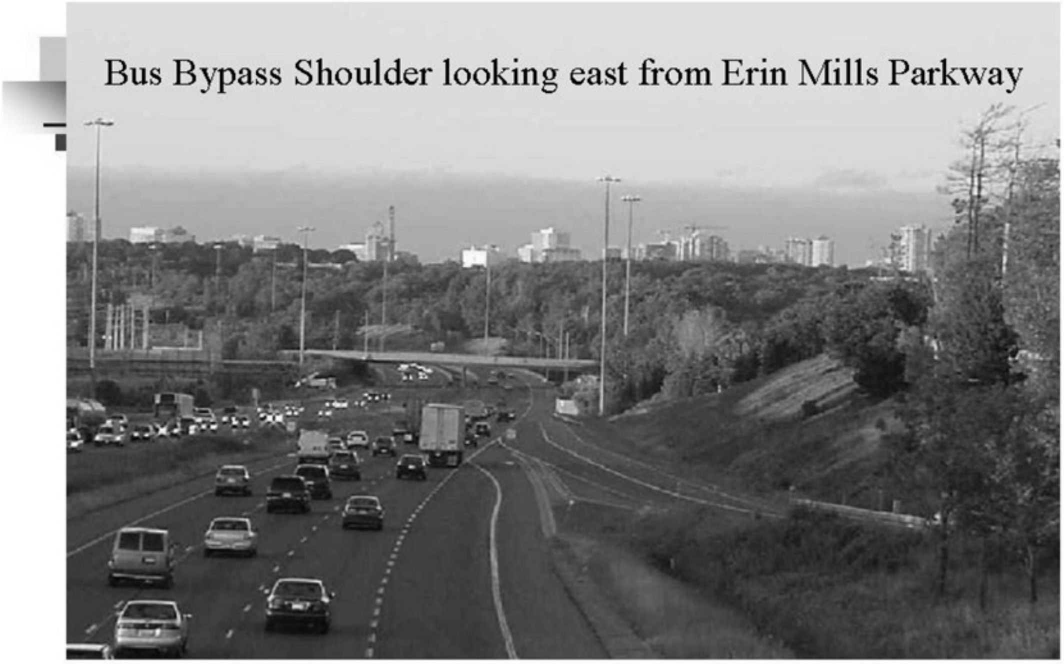
- In class presentation of the rules and regulations.
- Site visit of the BBS Lanes.
- Issue each driver a copy of the Operating Protocol for the BBS.
- Complete a written test.
- Each driver will complete a sign off sheet stating that 1) they have been trained on the BBS, 2) understand the rules and regulations, 3) will abide by the rules and regulations, and 4) have received a copy of the Operating Protocol.
- Issue each Driver with a BBS Operating Permit.

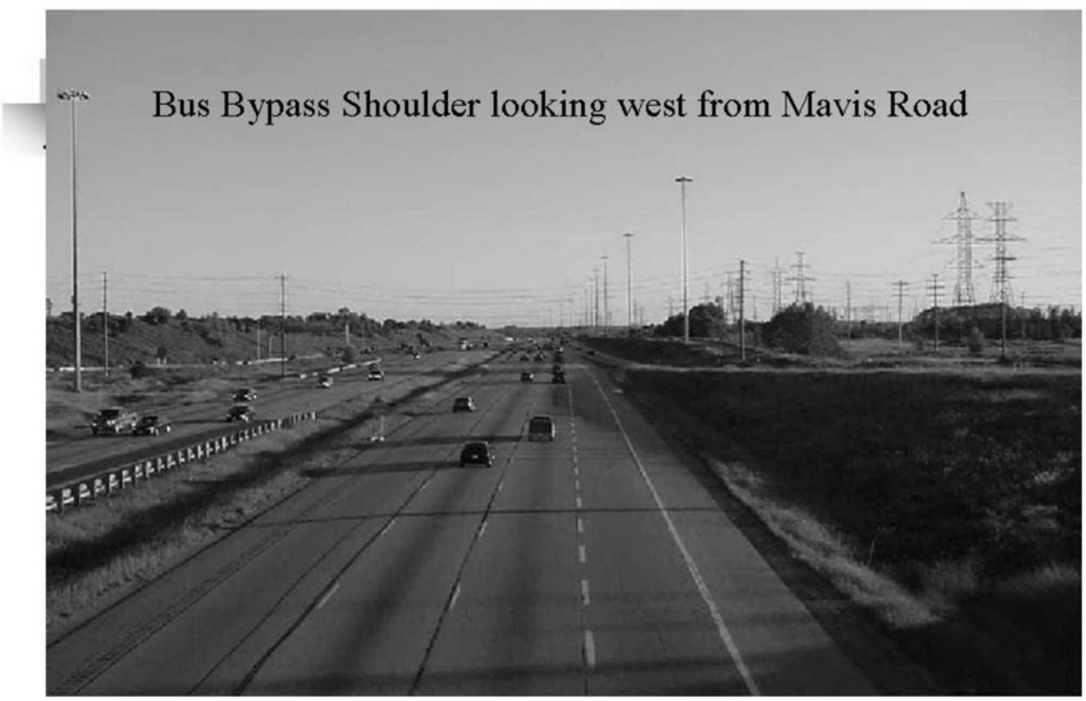
The Bus Bypass Shoulders are located on Highway 403 between Erin Mills Parkway in the west and



Mavis Road in the east. The Bus Bypass Shoulders are located on the right shoulders of both the eastbound and westbound lanes.




Bus Bypass Shoulder looking east from Erin Mills Parkway


Bus Bypass Shoulder looking west from Mavis Road

Criteria for Eligibility

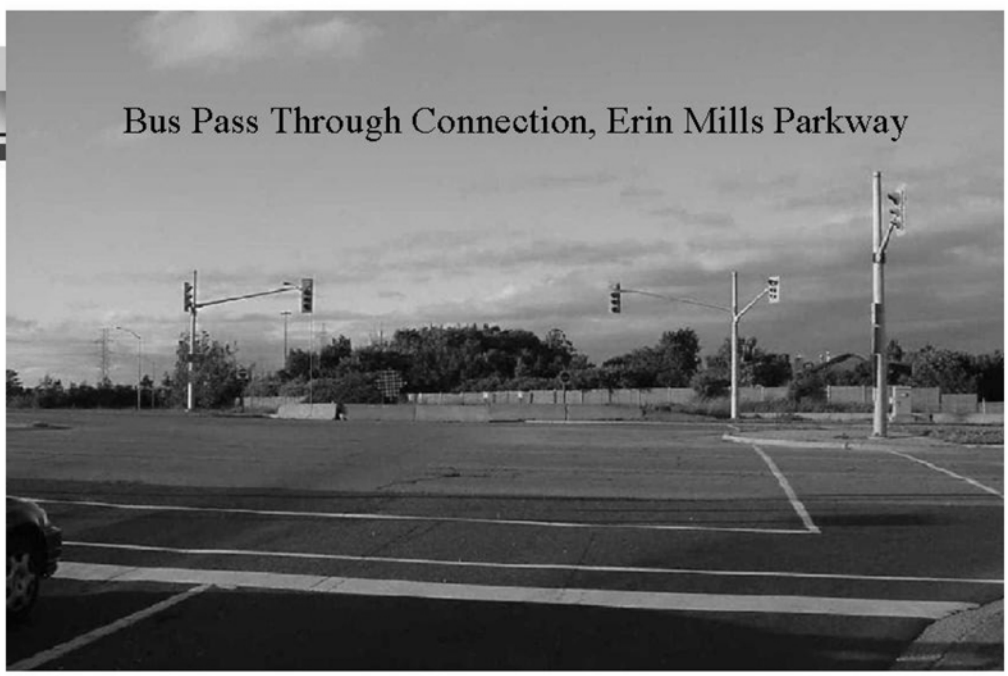
- Limited to those Bus Operators who are authorized by the Ministry of Transportation.
- Currently only GO Transit and Mississauga Transit are authorized.
- Additional Bus Operators may be permitted at a future time.
- Each Bus Operator must ensure that all bus drivers who will use the BBS have received a copy of the Operating Protocol.
- Each Bus Operator must ensure that drivers have been provided with training concerning the use of the BBS.
- Each Bus Driver must agree to the conditions of operating a bus in the BBS.
- GO Transit will provide the required training services to all Bus Operators using the BBS.
- Buses using the BBS must have radio or telephone contact with their central dispatcher, in order to report a blocked shoulder or other emergencies.
- Any information reported to their central dispatch must be immediately passed on to MTO COMPASS Operations, Downsview.

The Operating Partners

- The Ministry of Transportation
- GO Transit
- Mississauga Transit
- The Ontario Provincial Police

Location of the BBS

- Right Shoulder of the Highway 403 between Erin Mills Parkway and Mavis Road.
- A bus pass through connection is provided at the Erin Mills Parkway S-E ramp.
- The BBS is 3.75m wide, with rumble strips dividing the shoulder from the general purpose lanes.



Current Rumble Strip

Signage used to identify the BBS (Regulatory Signs)

Signage used to identify the BBS (Regulatory Signs)

Signage used to identify the BBS (Warning Sign)

Operating Speed

- Bus Drivers must exercise their best judgment in considering the safety of other motorists, as well as that of the bus passengers.
- Bus Drivers will only use the BBS when traffic in the GPL is moving at speeds equal to or less than 60 kmph.
- While using the BBS the bus shall not exceed 60 kmph.
- When the general-traffic on Highway 403 is in a stop and go condition buses are to travel no more than 20 kmph greater than the flow of traffic in the General Purpose Lanes

Collisions

- In the event of a collision in/adjacent to the BBS the Bus Operator's Central Dispatch must notify the appropriate emergency service first by calling 911 or the OPP at *677.
- The Bus Operator's Central Dispatch must then contact MTO COMPASS Operations, Downsview as soon as possible.
- The Bus Operator,s Central Dispatch will have a phone number for this purpose.This is not a public number and should not be used for any other purpose, or given to members of the public.

Obstruction of the BBS

- During winter months the BBS may be temporarily blocked by snow. Drivers will be responsible for exercising their best judgment in determining if they can safely utilize the BBS under these conditions.
- If the shoulder is obstructed in any way the driver must re-enter the GPL to avoid the obstruction. Bus drivers must yield to other vehicles when re-entering the GPL.
- Bus drivers are to notify their central dispatch of an obstruction who will then notify all other buses using the BBS of the obstruction. The BBS is not to be used until the obstruction is removed from the shoulder.
- Bus drivers in the BBS should safely exit the BBS to allow emergency vehicles to pass. If the shoulder is not blocked by an emergency, use of the BBS can resume once the emergency vehicle has passed.
- On occasion, The MTO/OPP may elect to utilize the BBS to detour general-purpose traffic. Except for emergency situations, MTO will attempt to provide the Bus Operators with at least 24 hours notice

Times of Use/Hours of Operation

- The BBS is to be used for traffic congestion bypass purposes only.
- Typically the BBS will be used on weekdays between the hours of 0600hrs - 1000hrs in the eastbound direction and 1600hrs – 1900hrs in the westbound direction.
- The BBS is typically not to be used on weekends unless an incident or event has resulted in the GPL operating at a speed of 60 kmph or less.
- The BBS may also be used for the duration of any prolonged congestion event outside of peak period hours, provided the speed of the traffic in the GPL lanes is 60 kmph or less.

Enforcement

- The OPP will provide a higher level of service as outlined to ensure safe and effective operation of the BBS.
  - A maximum of 6 peak hour enforcement periods per week for the first 2 weeks of initial operation.
  - 8 peak hour enforcement periods per week for the next four weeks.
  - The Port Credit Detachment will assign the officer to this area, however in an emergency situation the officer may be re-assigned.
  - The operating partners may request additional enforcement on a pay duty basis if it is considered necessary.
  - MTO will provide enforcement sites within the area of the BBS.
  - Following the initial six weeks of higher enforcement levels, enforcement will be occasional and provided when necessary and resources are available.

Facility Maintenance

- MTO will provide the same level of service for the BBS and the GPL.
- Due to the nature of the shoulder configuration, it may not always be possible to clear the shoulder as quickly as the GPL.
- Bus Drivers must use the GPL until the shoulders are fully cleared.
- Enforcement sites will not be cleared during the winter.

Access and Egress to the BBS

- General
  - As mentioned previously, bus drivers will only use the BBS when traffic in the GPL is moving at speeds equal to or less than 60 kmph.
  - While using the BBS buses shall not exceed 60 kmph.
  - When the GPL traffic on Highway 403 is in a stop and go condition buses are to travel no more than 20 kmph greater than the GPL flow of traffic.
  - **Once a bus has entered the BBS it shall not re-enter the GPL if the operating speeds of the GPL improves, but should continue to the end of the BBS.**

Eastbound Access, Situation 1

- When the operating speed of Highway 403 is less than or equal to 60 kmph prior to the ramp exit at Erin Mills Parkway buses are to
  - Exit at Erin Mills Parkway and enter the BBS from the dedicated bus ramp connection at the Erin Mills Parkway interchange.
  - When exiting eastbound buses must access the dedicated bus ramp connection from the center lane of the ramp.

Eastbound Access, Situation 2

- When Highway 403 traffic is operating at speeds greater than 60 kmph at Erin Mills Parkway but the operating speeds decrease beyond the Erin Mills Parkway interchange, buses will be allowed to enter the BBS at any location beyond the end of the speed change lane taper for the on ramp from northbound Erin Mills Parkway.
- As stated previously, once in the BBS buses are to remain there until they either exit at Mavis Road or merge with the GPL at the end of the BBS.

Eastbound Access, Situation 3

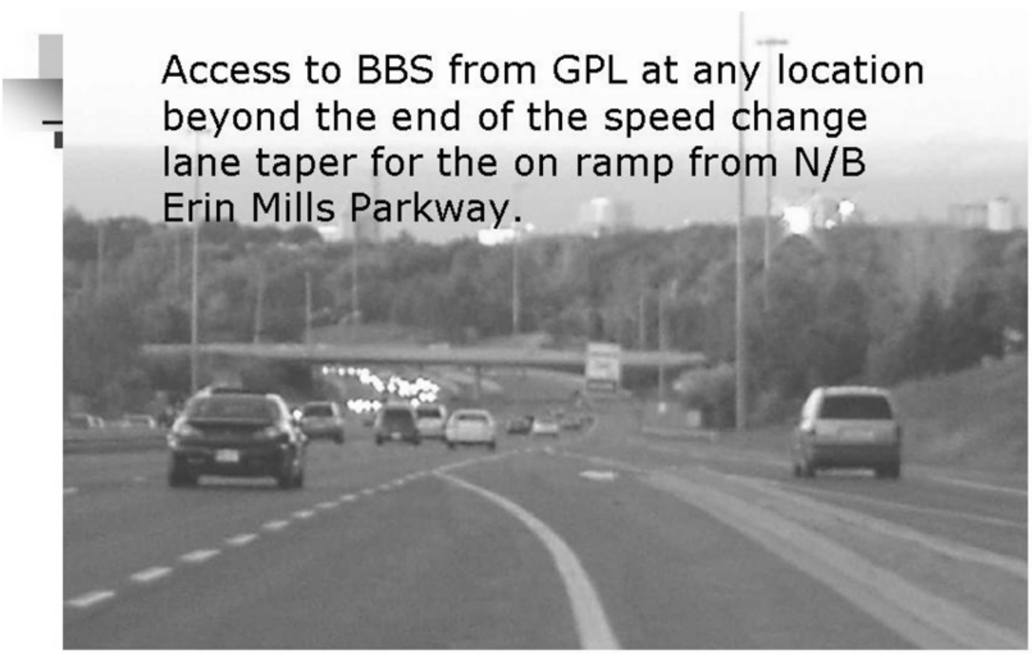
- Buses that are southbound on Erin Mills Parkway will access the dedicated bus ramp connection from the southbound bus only left turn lane.
- The southbound approach has a separate transit signal that will display a white bar when the buses are permitted to make a left turn.

Erin Mills Parkway exit from E/B 403


Dedicated Bus Ramp Connection
E/B 403 at Erin Mills Parkway


Southbound bus only left turn lane,
Erin Mill S/B at dedicated bus ramp


Dedicated Bus Ramp Connection


Access to BBS from GPL at any location
beyond the end of the speed change
lane taper for the on ramp from N/B
Erin Mills Parkway.

Exiting Eastbound, Situation 1

- Buses not exiting Highway 403 at the Mavis Road interchange will merge safely with the GPL traffic prior to the start of the speed change lane taper for the Mavis Road exit.

Exiting Eastbound, Situation 2

- Buses exiting at Mavis Road will continue in the BBS adjacent to the ramp and enter the right turn lane with the ramp traffic when it is safe to do so.


E/B buses exiting the BBS to the GPL must do so before the Mavis Road exit ramp


Buses exiting at Mavis Road will continue in the BBS and enter the right turn lane when it is safe to do so.
80

Westbound Access, Situation 1

- Buses entering Highway 403 via the Mavis Road N/B to Hwy. 403 W/B ramp will merge with the GPL and enter the BBS beyond the end of the speed change taper of the Hwy. 403 on ramp from Mavis Road S/B when it is safe to do so.
- **At no time will a bus enter the southbound Mavis Road to Highway 403 on ramp speed change lane in order to access the BBS.**

Westbound Access, Situation 2

- Buses already traveling on the Highway 403 W/B prior to Mavis Road must enter the BBS beyond the end of the Mavis Road S/B on ramp speed change lane taper when it is safe to do so.
- **At no time will a bus enter the S/B Mavis Road to Highway 403 on ramp speed change lane in order to access the BBS.**

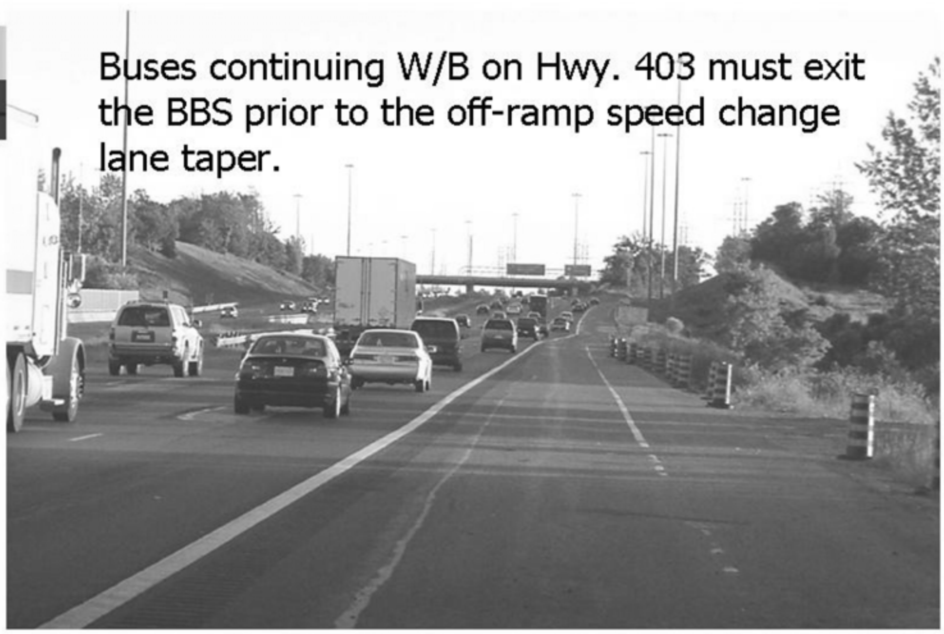
Exiting Westbound, Situation 1

- Buses continuing west on Highway 403 west of Erin Mills Parkway must exit the BBS and merge safely with the GPL.
- This must be done prior to the start of the off-ramp speed change lane taper for the Erin Mills Parkway exit.

Exiting Westbound, Situation 2

- Buses exiting at Erin Mills Parkway will continue in the BBS lane adjacent to the off ramp.
- Buses will continue on the shoulder and enter the right turn lane with ramp traffic when it is safe to do so.

Buses continuing W/B on Hwy. 403 must exit the BBS prior to the off-ramp speed change lane taper.



W/B buses exiting at Erin Mills Parkway will continue in the BBS and join the ramp traffic when it is safe to do so.

Reporting and Liaison Reporting of Collisions

- In addition to contacting the appropriate emergency services at the time of a collision, the Bus Operators will report to the MTO the details of any collisions involving their vehicles immediately after their occurrence.
- Details will include:
  - Date, time and location of the incident
  - Traffic, weather, and pavement conditions at the time
  - Vehicles involved
  - Sequence of events
  - Damages and injuries
  - Possibility of charges
  - Recommended measures to avoid recurrence of the incident.
- The report is to be e-mailed or faxed to the designated MTO contact.

Reporting and Liaison Forecast of Use

- On a bi-annual basis, Sept 1 and April 1 each Bus Operator is to provide to the MTO a letter outlining:
  - Bus routing, schedule and bus volumes or the upcoming 6 months.
  - Estimate of total trips (peak period and per day) in both directions.
- This letter is to be sent to the designated MTO Contact
- The Ministry will provide written approval for the use of the BBS.
- Each Bus Operator can add bus services to the BBS to within 25% over the submitted estimate before having to obtain further written approval from the MTO.
- The Ministry will determine if additional buses or changes to the operating times will be permitted beyond this agreed estimate.

Reporting and Liaison Bi-Annual Meetings

- The Operating Partners will meet on regular basis
- At least Bi-annually
- The purpose of the meetings will be to:
  - Review BBS operations
  - Agree on changes and improvements

Reporting and Liaison
Evaluation of BBS use

- The Ministry will monitor the operation of the BBS and assess the impacts of the BBS on the GPL.
- The Ministry will report to the Bus Operators and the OPP any observed problems or violations of this Operating Protocol, including excessive speed on the BBS or unsafe merging activity.
- The Ministry will notify the Bus Operator when a problem has been observed and issue a warning that the Ministry may cancel this Operating Protocol if further violations are observed.

Reporting and Liaison
Media Releases

- Any media releases pertaining to the BBS will be shared, in confidence with all Operating Partners, at least 24 hours in advance of its release.

Designated Contacts

- Any changes ot the designated contacts must be provided within one (1) week to the other Operating Partners.
- MTO
  - Mr Fabio Saccon, Area Traffic Manager, Central Region Traffic Office
- OPP
  - Inspector Alex Kehoe, Regional Director Operations – Greater Toronto Regional Headquarters
- GO Transit
  - Mr. Paul Finnerty, Manager Bus Operations
- Mississauga Transit
  - Mr. Gord Wright, Manager Service Delivery

Termination of Operations

- With the exception of an emergency, any of the Operating Partners may terminate their participation in their BBS Operation with 30 days notice, in writing, to the designated contacts of the other Operating Partners.
- MTO reserves the right to terminate/suspend operations, with minimal or no notice if, in the opinion of the Ministry's Regional Director, there are significant traffic safety or operational concerns.

Liability

- The Ministry is not liable for consequences that may result from termination of the operation of the BBS.
- By utilizing the shoulders and agreeing to this Operating Protocol the Bus Operators acknowledge and accept the more limited operating conditions of the BBS compared to the highway general purpose lane.

Appendix A
Eligibility Criteria for Use of BBS

- Transit Operators using the BBS must have a Commercial Vehicle Operator's Registration (CVOR)
- Must have a Carrier Safety Rating of either excellent or satisfactory.
- The Bus Operator must provide regular, scheduled service available to the public.
- The Ministry's Central Region designated contact must be provided with proof of this rate.
- Only 40' to 60' buses and articulated transit buses will be permitted to use the BBS.

In Closing

- **In order to use the BBS lanes the**
  - **Bus Operator must have authorization from the MTO to use the BBS.**
  - **The Bus Driver must have attended and passed a training session on the BBS.**
  - **The Bus Driver must have in his/her possession a valid BBS Operators Permit**

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation